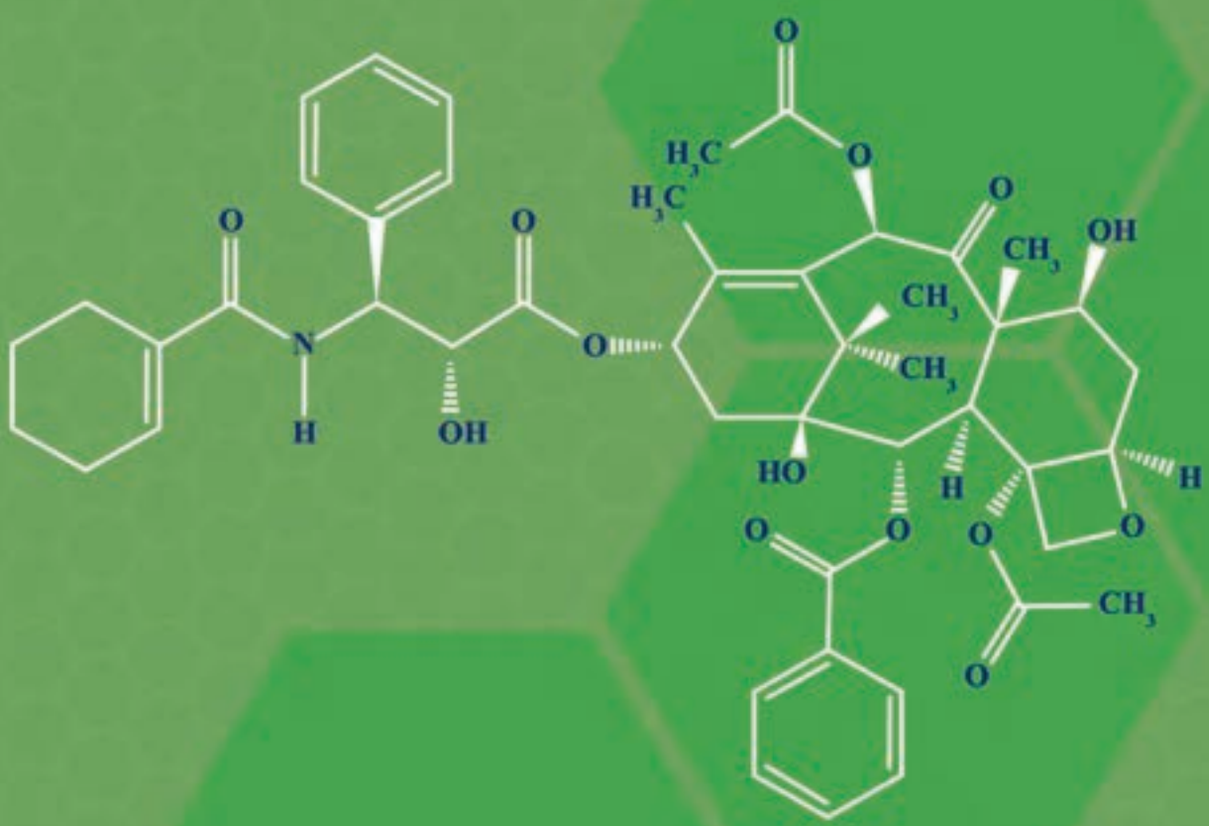
Neap Assessment Series

NSW CHEMISTRY Year 12



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Neap

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NSW Year 12 Chemistry

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We acknowledge the Wurundjeri people of the Kulin nation as the traditional owners of the land on which this text was created. We pay our respects to Elders past, present and future and acknowledge that this land we work on has, and always will be, Wurundjeri land.

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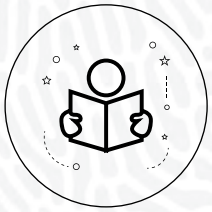


PREFACE

This book covers material in Modules 5, 6, 7 and 8 in the NSW Education Standards Authority (NESA) Year 12 Chemistry course.

The purpose of this book is to give you a greater understanding of the HSC Chemistry course by providing you with an extensive set of exam-style questions. At the beginning of each module there is a brief description of the material covered as well as key terms with definitions. Each module is broken down into topics which consist of multiple-choice and short-answer questions covering all content specified in the HSC syllabus in detail.

The content is broken down into questions of varying difficulty levels that emulate the standards expected by NESA. This will hopefully enable you to develop the skills to later tackle difficult full-length questions with greater success. The difficulty level for each question is indicated on a scale of 1–5, 1 being the easiest and 5 being the hardest.

The Challenge Questions are designed to provide you with the opportunity to attempt more complex question types that draw on content across entire modules. These questions will complement and add a broader understanding and knowledge of the syllabus.

In-depth answers are provided for each question, including step-by-step working where calculations are required. In addition, syllabus outcomes, HSC targeted performance bands and marking schemes are shown. This provides you with greater knowledge of content as well as an awareness of the markers' expectations which will prepare you for future examinations.

It is important to note that the sample answers are designed to give complete coverage of all possible solutions and you may obtain full marks by giving less detailed responses.

You are expected to have access to the NESA data booklet (this includes a periodic table) and a NESA approved calculator when completing these questions. It is strongly recommended that you use a current NESA syllabus to check your coverage of the course as you work through this book.

Peter Gribben

MODULE 5
Equilibrium and acid reactions

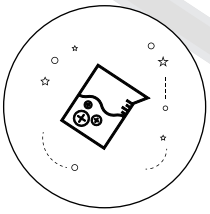
TOPIC 1: Static and dynamic equilibrium

TOPIC 2: Factors that affect equilibrium

TOPIC 3: Calculating the Equilibrium Constant (K_{eq})

TOPIC 4: Solution equilibria

This module focuses on the standard way of looking at reactions using equations such as $A + B \rightarrow C + D$, where the arrow shows that the reaction goes from left to right from reactants *A* and *B* to products *C* and *D*. Reactions which can be made to go backwards, such as $C + D \rightarrow A + B$ by, for example, altering reaction conditions are called reversible reactions. Some reactions can go in both directions at the same time. Eventually a balance or equilibirum is reached, where the rates of forward and reverse reactions are equal. You will also learn how to calculate the equilibrium constant (K_{eq}) which is the ratio of products to reactants at equilibrium.



MODULE 5 TOPIC 1

Static and dynamic equilibrium

This topic looks at reactions that do not go to completion. You will cover two types of equilibrium reactions: **static equilibrium**, which occurs when a system has ceased to change, and **dynamic equilibrium**, which involves a constant interchange between reactants and products. These reactions may be in **open** or **closed systems**. You will also learn about the relationship between **enthalpy** (*H*), **entropy** (*S*) and **Gibbs free energy** (*G*) on non-equilibrium systems. Finally, you will cover the fundamentals of **collision theory** and the rules governs whether substances will react.

STATIC EQUILIBRIUM
This occurs when the rates of the forward and reverse reactions are zero, meaning there is no exchange between reactants and products.

DYNAMIC EQUILIBRIUM
This occurs when the rates of the forward and reverse reactions in a reversible reaction are equal.

OPEN SYSTEM
An open system can exchange both energy and matter with its surroundings.

CLOSED SYSTEM
A closed system can exchange energy with its surroundings, but the reactants and products cannot enter or escape.

ENTHALPY
Enthalpy refers to the total heat content of a system.

ENTROPY
Entropy refers to the degree of disorder or randomness in a system.

GIBBS FREE ENERGY
Gibbs free energy combines enthalpy and entropy into the equation $\Delta G = \Delta H - T\Delta S$. A negative value means that a reaction is spontaneous, whereas a positive value means that it is not spontaneous.

COLLISION THEORY
Collision theory states that for substances to react, they must collide with enough energy and with the correct orientation.

Use the difficulty indicators to gauge your understanding of each topic.

least challenging most challenging

Question 1.1

Reversible reactions

A. are always spontaneous.

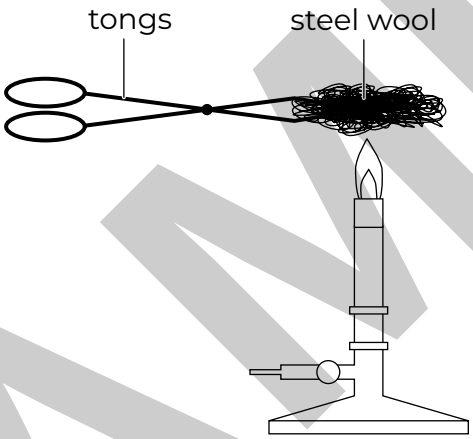
B. are always exothermic.

C. involve reactants going to products and reactants leaving products.

D. are purely hypothetical.

Question 1.2

Steel wool can be set alight by a hot Bunsen burner flame and continue to burn in the air as shown in the diagram.



Which of the following statements about this reaction is NOT accurate?

A. It is an example of combustion.

B. It is an example of a closed system.

C. The reactants are iron and oxygen and the product is iron oxide.

D. It is irreversible.

Question 1.3

Which of the following rows correctly corresponds with the symbols that describe the thermodynamic properties of a system?

	ΔG	ΔH	ΔS
A.	change in Gibbs free energy	change in heat	change in randomness
B.	total Gibbs free energy	total heat content	total randomness
C.	initial Gibbs free energy	initial heat content	initial randomness
D.	final Gibbs free energy	final heat content	final randomness

Question 1.4

Diamond and graphite are both forms of carbon and can be changed to one another depending on the conditions. Graphite is more stable than diamond and diamond will change to graphite, if heated to around 2000°C in the absence of air. However, it has been estimated that at standard conditions (25°C and 100kPa), this process would take millions of years.

Under standard conditions, the change of diamond to graphite is best described as

A. a redox reaction.

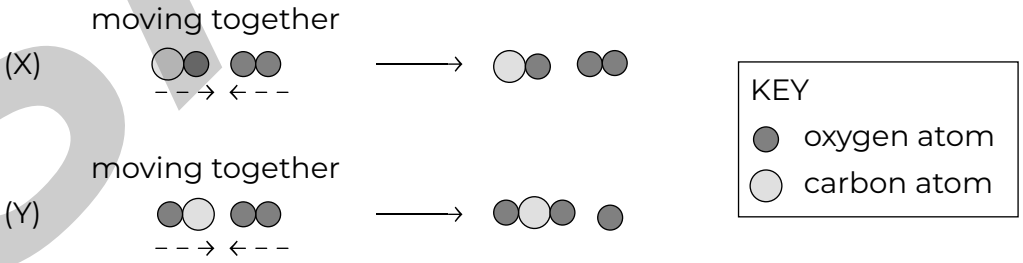
B. decomposition.

C. an example of static equilibrium.

D. an example of dynamic equilibrium.

Question 1.5

The diagram shows the interactions between carbon monoxide and an oxygen molecule.



The diagram is demonstrating

A. activation energy.

B. the effect of concentration on a reaction.

C. how enthalpy changes occur in a reaction.

D. collision theory.

Question 1.6 (2 marks)

A student heats a sample of hydrated cobalt (II) chloride (pink) and it turns to dehydrated cobalt (II) chloride (sky blue). **2**

Identify whether this reaction is reversible and explain your answer with a description of the reactions.

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Question 1.7 (2 marks)

A Year 12 chemistry textbook states: **2**

The reaction rate is affected by the speed of particles of the reacting substances.

Explain how the reaction rate is affected by the speed of the particles giving at least TWO relevant reasons.

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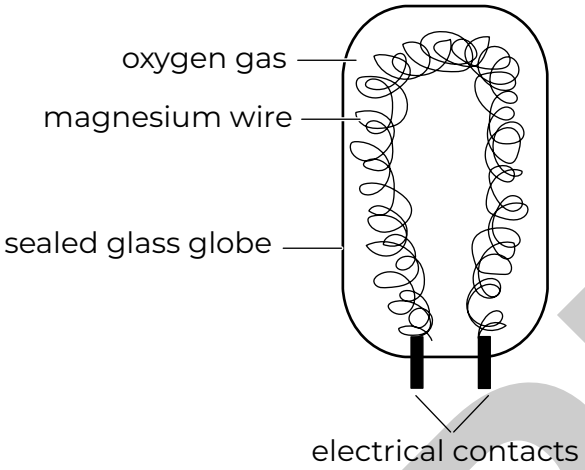
Question 1.8 (2 marks)

Fill in the table by identifying whether enthalpy and entropy either increase or decrease in photosynthesis and combustion reactions. **2**

Photosynthesis		*Combustion*	
Enthalpy	Entropy	Enthalpy	Entropy

Question 1.9 (3 marks)

The diagram below shows a flash bulb. Flash bulbs were used in the past to take photographs. They consist of coils of thin magnesium wire, surrounded by oxygen in a sealed glass globe. When a current passes through the wire the magnesium heats up and combines with the oxygen instantaneously, giving out heat and light.



(a) Identify the compound formed. **1**

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(b) Identify whether the flash bulb is an open system or a closed system. Give at least TWO relevant reasons. **2**

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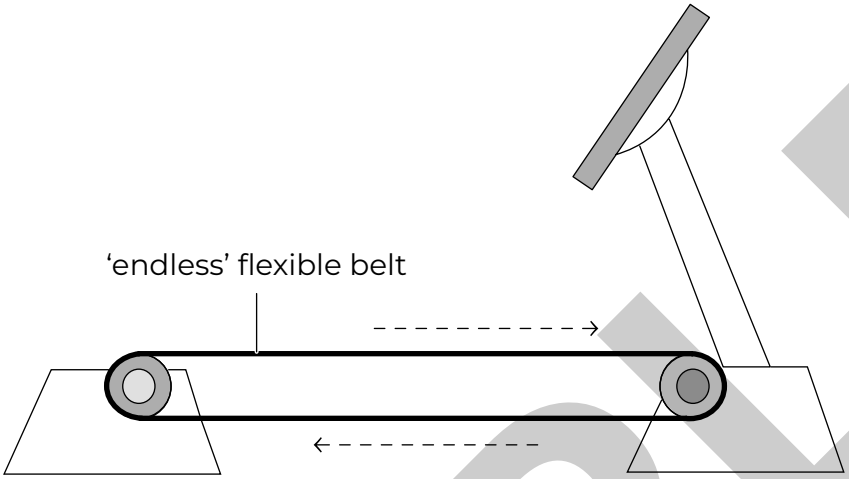
Question 1.10 (5 marks)

A teacher tried to explain a chemical concept to their class and used a treadmill as a model, shown below. The teacher explained that the belt moves to the rear of the treadmill, which makes the user walk or run to match the speed of the belt.



(a) Identify and describe the concept being modelled here. **3**

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(b) Evaluate how well the treadmill scenario models this concept, giving at least ONE supporting reason and ONE opposing reason for the suitability of the model. **2**

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Question 1.11 (6 marks)

The following equation shows a reaction involving three different species. The colour of each species is shown below the equation.

$Fe^{3+}(aq)$ + SCN^- 'react together' $FeSCN^{2+}(aq)$
(yellow) (colourless) (blood-red)

(a) Identify each of the following species.

(i) Fe^{3+} **1**

.....

(ii) SCN^- **1**

.....

(iii) $FeSCN^{2+}$ **1**

.....

(b) The equation above says that the species 'react together'. **2**

What sort of reaction occurs between these species? Justify your answer with reference to the equation above.

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(c) Draw the appropriate symbol that could be used to replace 'react together', for this particular reaction. **1**

TOTAL MARKS: /25

Solutions

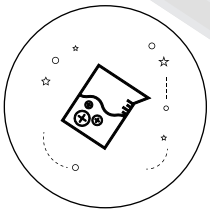
Answer and explanation	Syllabus outcomes, targeted performance bands and marking guide
Question 1.1 C **C** is correct. A reversible reaction is a chemical reaction where the reactants form products that, in turn, can react together to give the reactants back. Reversible reactions may be spontaneous but do not have to be, so **A** is incorrect. They can be exothermic or endothermic, so **B** is incorrect. Reversible reactions do exist, so **D** is incorrect.	CH12–12 Band 2
Question 1.2 B **B** is correct. The reaction occurs between iron and oxygen in the air (combustion), which is an open system, not a closed system. Iron oxide cannot be turned back into iron and oxygen without the expenditure of a great deal of energy.	CH12–12 Band 2
Question 1.3 A **A** is correct; the Δ (delta) symbol means that it refers to a 'change'. Hence, **B**, **C** and **D** are incorrect as none mention a change.	CH12–12 Bands 2–3
Question 1.4 C **C** is correct. Static equilibrium is a type of equilibrium in which the rates of the forward and reverse processes are zero. As the equilibrium reaction C (diamond) $\rightleftharpoons$ C (graphite) proceeds so slowly under standard conditions, both rates can be considered as zero. There is no change of oxidation state, so **A** is incorrect. It is a physical change not a chemical one, so **B** is incorrect. Dynamic equilibrium has a constant interchange between reactants and products, so **D** is incorrect.	CH12–6 Band 3

Answer and explanation	Syllabus outcomes, targeted performance bands and marking guide
Question 1.5 D **D** is correct. There is no indication of energy or different numbers of particles shown in reactions *X* and *Y*. The diagram shows that no reaction occurs when an oxygen atom collides with an oxygen atom (in *X*). Whereas a reaction does occur when a carbon atom collides with an oxygen atom (in *Y*). This means that a reaction will occur only at a specific orientation (*Y*), so the diagram must be referring to collision theory.	CH12–6, 12–12 Bands 4–5
Sample answer	**Syllabus outcomes, targeted performance bands and marking guide**
Question 1.6	
The reaction is reversible because if water was added to the dehydrated sky blue coloured cobalt (II) chloride, ($CoCl_2$) it would return to its original pink colour which is the hydrated cobalt (II) chloride ($CoCl_2.6H_2O$).	CH12–4, 12–12 Band 2 • Gives the correct answer. AND • Gives detailed descriptions of reactions. 2 • Gives the correct answer. AND • Gives some descriptions of reactions. 1
Question 1.7	
Collision theory states that particles must collide with sufficient energy to react. The greater the speed of the particles the greater the (kinetic) energy.	CH12–12 Band 3 • Explains how the reaction rate is affected making at least TWO relevant points. 2 • Explains how the reaction rate is affected making ONE relevant point. 1

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
Question 1.8	
<table><tr><td colspan="2">Photosynthesis</td><td colspan="2">Combustion</td></tr><tr><td>Enthalpy</td><td>Entropy</td><td>Enthalpy</td><td>Entropy</td></tr><tr><td>increases</td><td>decreases</td><td>decreases</td><td>increases</td></tr></table>	CH12–12 Band 3 • Identifies all FOUR terms correctly. 2 • Identifies at least TWO terms correctly. 1
Question 1.9	
(a) magnesium oxide	CH12–6, 12–12 Band 1 • Gives correct name of the compound. 1
(b) It is a closed system. Energy (for example, light) can escape through the glass, but all the matter is sealed inside the globe and cannot exchange with the surrounds.	CH12–12 Bands 3–4 • Gives the correct type of system. AND • Makes at least TWO relevant points. 2 • Gives the correct type of system. AND • Makes ONE relevant point. 1

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
Question 1.10	
(a) The concept is dynamic equilibrium. At equilibrium, the reaction rate of the forward reaction is equal to the reaction rate of the backward reaction. Although there is no visible change (macro level) there is a change at the particle level (micro level).	CH12–4, 12–6, 12–12 Band 5 • Correctly identifies the concept. AND • Describes the concept in detail. 3 --- • Correctly identifies the concept. AND • Gives some details of the concept. 2 --- • Correctly identifies the concept. 1
(b) The user is moving forward (forward reaction) at the same speed as the belt in the other direction (reverse reaction) so no obvious change is taking place, and user stays in the same place. It does not address the change at particle level. Therefore, the treadmill scenario models this concept only reasonably well.	CH12–2, 12–12 Bands 5–6 • Gives reasons supporting the model. AND • Gives reasons against the model. 2 --- • Gives reasons supporting the model. OR • Gives reasons against the model. 1
Question 1.11	
(a) (i) iron (III)	CH12–12 Bands 1–2 • Gives the correct name. 1
(ii) thiocyanate	CH12–12 Bands 1–2 • Gives the correct name. 1
(iii) iron (III) thiocyanate	CH12–12 Bands 1–2 • Gives the correct name. 1

	Sample answer	Syllabus outcomes, targeted performance bands and marking guide
(b)	An equilibrium (reversible) reaction occurs. The position of equilibrium can be changed by changing the concentration of products or reactants. This is seen in the equation, where the colour will become more red if the equilibrium shifts to the right and forms more $FeSCN^{2+}$. The colour will become more yellow if the equilibrium shifts further in the reverse direction and forms more Fe^{3+}.	CH12–6, 12–12 Band 5 • Correctly identifies the type of reaction. AND • Gives a detailed explanation. 2 --- • Correctly identifies the type of reaction. AND • Gives some details. 1
(c)	(the equilibrium symbol) $\rightleftharpoons$	• CH12–12 Band 2 • Draws the correct symbol. 1



MODULE 5 TOPIC 2

Factors that affect equilibrium

This topic looks at the factors that can affect both **endothermic** and **exothermic** reactions, including changes in temperature, concentration, volume and pressure. All of these can impact the amount of products and reactants in an equilibrium system, and hence the **activation energy** required for a reaction. You will also learn about **Le Chatelier's principle** which defines how the **position** of a dynamic equilibrium changes in order to counteract changes to the system. This helps us to forecast the effects of changes on an equilibrium system. Activation energy (E_a) and **heat of reaction** (ΔH) also affect the position of equilibrium. This topic will also introduce **hydrogen reaction profiles** which can give us more information about the activation energy and enthalpy of a reaction.

ENDOTHERMIC REACTION
An endothermic reaction is one which absorbs heat energy to form products.

EXOTHERMIC REACTION
An exothermic reaction is one which releases heat energy to form products.

ACTIVATION ENERGY
The activation energy is the minimum amount of energy required to cause a reaction.

LE CHATELIER'S PRINCIPLE
Le Chatelier's principle states that a change in a system in dynamic equilibrium will cause the position of equilibrium to shift to counteract that change.

POSITION OF EQUILIBRIUM
The position of equilibrium refers to the point in a chemical reaction where the concentrations of reactants and products are no longer changing.

HEAT OF REACTION (ΔH)
The heat of reaction refers to the energy that is absorbed or released in a chemical reaction where pressure is constant.

HYDRATE REACTION PROFILE
This is a diagram that shows the activation energy and enthalpy change as a reaction goes from reactants to products.

Use the difficulty indicators to gauge your understanding of each topic.

least challenging most challenging

Question 2.1

The position of equilibrium of a reaction occurs when

A. the reaction rate is fastest.

B. the conditions are changed in the reaction.

C. the amount of reactants equals the amount of products.

D. the overall concentrations of reactants and products are no longer changing.

Question 2.2

Which of the following statements about equilibrium reactions is correct?

A. They do not typically go to completion.

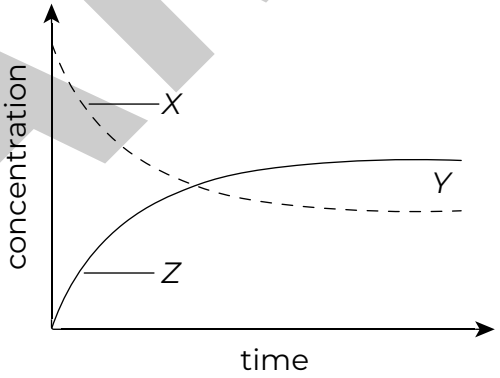
B. They only occur in open systems.

C. They are usually endothermic regarding the forward reaction.

D. They only occur in aqueous solutions.

Question 2.3

The diagram shows how concentration changes with time in an equilibrium reaction.

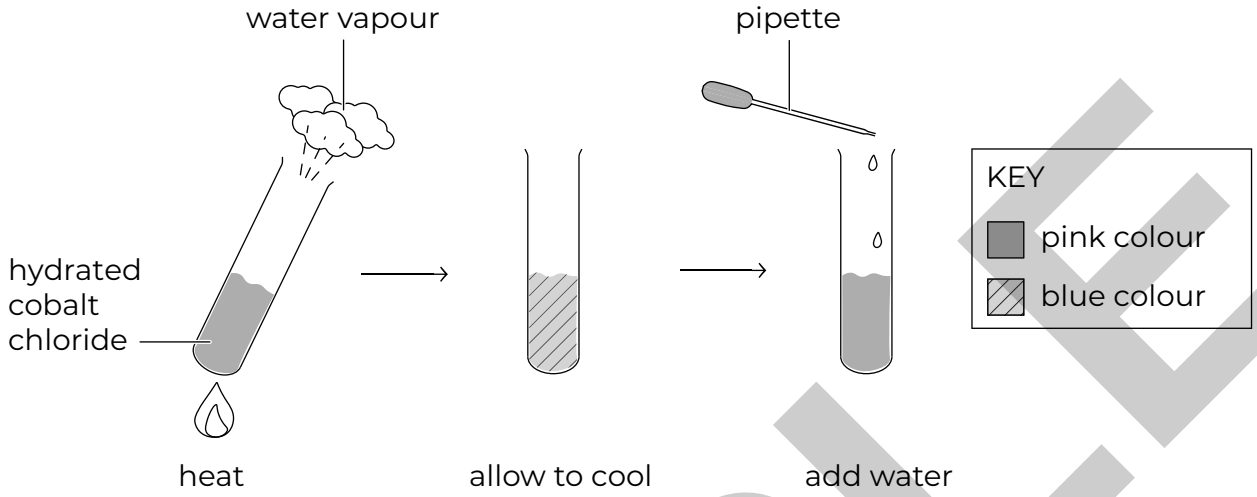


Which of the following correctly identifies *X*, *Y* and *Z*?

	X	*Y*	*Z*
A.	products	reactants	equilibrium
B.	reactants	equilibrium	products
C.	equilibrium	products	reactants
D.	reactants	products	equilibrium

Question 2.4

The diagram shows the stages in an experiment using cobalt (II) chloride hydrate.



When heated, cobalt (II) chloride hydrate loses water and turns from pink to blue in colour as shown in the equation:

$$CoCl_2(6H_2O)(s) \rightarrow CoCl_2(s) + 6H_2O(l)$$

When water is added it turns from pink to blue in colour as shown in the equation:

$$CoCl_2(s) + 6H_2O(l) \rightarrow CoCl_2(6H_2O)(s)$$

Which of the following statements about this experiment is correct?

A. It demonstrates an equilibrium system.

B. It is investigating the effect of heat on the rate of reaction.

C. It is a reversible reaction.

D. It is a decomposition reaction.

Question 2.5

When additional reactant is added to a system at equilibrium, the rate of the forward reaction increases.

This increase is explained by

A. Le Chatelier's principle.

B. collision theory.

C. the enthalpy change of the reaction.

D. the activation energy of the reaction.

Question 2.6 (6 marks)

The equation below shows the colours of the cobalt (II) ion in an equilibrium reaction. Le Chatelier's principle is often used in conjunction with equilibrium reactions.

$$\underset{\text{(pink)}}{\left[Co(H_2O)_6\right]^{2+}(aq)} + 4Cl^-(aq) \rightleftharpoons \underset{\text{(blue)}}{\left[CoCl_4\right]^{2-}(aq)} + 6H_2O(l) \qquad \Delta H = +ve$$

(a) What is the term used when referring to a species when it has molecules of water attached? **1**

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(b) Outline Le Chatelier's principle. **2**

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(c) What would happen to these concentrations of $[Co(H_2O)_6]^{2+}$ (aq) and $[CoCl_4]^{2-}$ (aq) if an equilibrium mixture was heated? Explain your answer. **3**

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Question 2.7 (5 marks)

The equation shows an equilibrium reaction between two gases.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -ve$$

(a) Write the names of the TWO molecules present. **1**

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(b) Draw a table to show the change in products affected by an increase in temperature AND an increase in pressure, AND products being removed. Give a brief reason for each answer. Assume that the system is at standard conditions (100 kPa and 25°C), and that for each change all other conditions are kept the same. **4**

Question 2.8 (3 marks)

The iron (III) (Fe^{3+}) ion and thiocyanate ion (SCN^-), react in aqueous solution to form the iron(III) thiocyanate ion, ($Fe(SCN)^{2+}$): **3**

$$\underset{\text{(yellow)}}{Fe^{3+}(aq)} + \underset{\text{(colourless)}}{SCN^-(aq)} \rightleftharpoons \underset{\text{(brick-red)}}{Fe(SCN)^{2+}(aq)}$$

A scientist examined an equilibrium mixture of these ions. The mixture had an intense red colour. The scientist altered the conditions so as to decrease the amount of iron(III) (Fe^{3+}) and thiocyanate (SCN^-) present.

What would the visible change be in the mixture after the alteration? Give detailed reasoning to support your answer.

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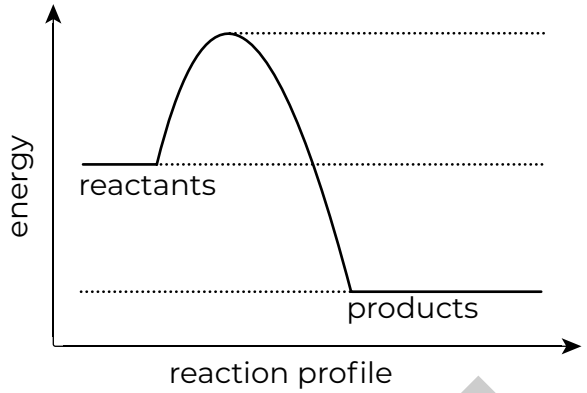
Question 2.9 (6 marks)

The diagram shows a reaction profile for an equilibrium reaction.



(a) On the diagram above, label the activation energy (*Ea*) for both the forward AND the reverse reaction. **2**

(b) Define 'activation energy'. **1**

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(c) Explain how activation energy affects the position of equilibrium in the diagram above. Refer to both forward reactions and reverse reactions in your answer. **3**

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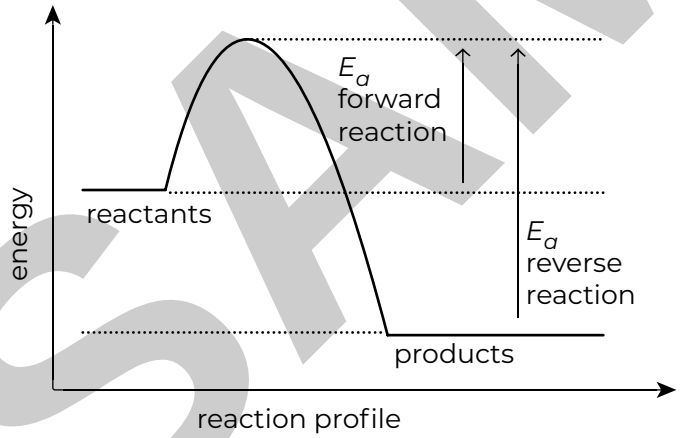
TOTAL MARKS: /25

Solutions

Answer and explanation	Syllabus outcomes, targeted performance bands and marking guide
Question 2.1 D **D** is correct. At equilibrium, the quantities of everything present in the mixture remain constant, although the reactions still continue. The reaction rate is usually fastest at the beginning, so **A** is incorrect. When conditions are changed this alters the position of equilibrium, so **B** is incorrect. The concentrations at equilibrium will vary considerably, so **C** is incorrect.	CH12–12 Bands 1–2
Question 2.2 A **A** is correct. At equilibrium there is always a mixture of reactants and products, therefore the reaction does not go to completion. Equilibrium reactions can occur in both open and closed systems, so **B** is incorrect. They can be exothermic and endothermic in forward reactions, so **C** is incorrect. They can occur in liquid and gaseous form as well as in solution, so **D** is incorrect.	CH12–12 Band 2
Question 2.3 B **B** is correct. In an equilibrium reaction the concentration of reactants starts at a maximum, decreases, and levels off. The concentration of products starts at a minimum, increases and levels off. Equilibrium occurs when neither concentration is changing. **A**, **C** and **D** do not fulfil these conditions, and are incorrect.	CH12–6, 12–12 Band 3
Question 2.4 C **C** is correct; when water is added to the solution it returns to its original form (cobalt (II) chloride hydrate), hence this is a reversible reaction. It cannot be an equilibrium system because it is an open system, so **A** is incorrect. No measurement of rate is given and it is only losing water, not decomposing, so **B** and **D** are incorrect.	CH12–6, 12–12 Bands 2–3
Question 2.5 B **B** is correct. This reaction involves a change in reactant concentration and does not involve heat or activation energy. According to collision theory, this increases the number of collisions of reactant molecules and therefore increases the rate of the forward reaction. **C** and **D** are incorrect. Le Chatelier's principle only predicts, it does not explain, so **A** is incorrect.	CH12–12 Band 4

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
Question 2.6	
(a) hydrated	CH12–12 Bands 1–2 • Gives the correct term. 1
(b) If a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium shifts to counteract the change to re-establish an equilibrium.	CH12–12 Bands 2–3 • Gives a comprehensive outline of Le Chatelier's principle. 2 --- • Gives a partial outline of Le Chatelier's principle. 1
(c) The concentration of $[Co(H_2O)_6]^{2+}$ (*aq*) would decrease and that of $[CoCl_4]^{2-}$ (*aq*) would increase (the colour of the mixture would become blue). This is an endothermic reaction (left to right) and Le Chatelier's principle states that an energy input would reinforce reactants to products.	CH12–12 Band 3 • Correctly describes changes in concentration of BOTH substances. AND • Gives a correct explanation mentioning energy change of reaction. AND • Refers to Le Chatelier's principle. 3 --- • Correctly describes changes in at least ONE substance. AND • Gives a correct explanation mentioning energy change of reaction. OR • Refers to Le Chatelier's principle. 2 --- • Correctly describes changes in at least ONE substance. OR • Gives a correct explaination of energy change of reaction. OR • Refers to Le Chatelier's principle. 1

<table>
<tr><th>Sample answer</th><th>Syllabus outcomes, targeted performance bands and marking guide</th></tr>
<tr><td>Question 2.7</td><td></td></tr>
<tr><td>(a) NO_2 is nitrogen dioxide.
N_2O_4 is dinitrogen tetroxide.</td><td>CH12–12 Bands 1–2
· Correctly identifies BOTH molecules. 1</td></tr>
<tr><td>(b)
<table>
<tr><th></th><th>Temperature increase</th><th>Pressure increase</th><th>Products removed</th></tr>
<tr><td>change in products</td><td>decrease
Exothermic reaction, system reacts to remove heat (reverse reaction).</td><td>increase
Products to reactants is 2 volumes to 1 volume. Pressure increase favours forward reaction.</td><td>initially decrease
System reacts to oppose change and to replace the products. Equilibrium will shift to the right and favour the forward reaction.</td></tr>
</table></td><td>CH12–6, 12–7, 12–12 Band 4
· Draws an appropriate table.
AND
· Gives the correct effects of all THREE changes.
AND
· Gives appropriate reasons for all THREE changes. 4
———
· Draws an appropriate table.
AND
· Gives the correct effects of TWO changes.
AND
· Gives appropriate reasons for TWO changes. 3
———
· Draws a table.
AND
· Gives the correct effects of TWO changes.
OR
· Gives appropriate reasons for TWO changes. 2
———
· Gives some useful information. 1</td></tr>
</table>

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
Question 2.8	
After the alteration, the brick-red colour would become less intense. This would occur as it is an equilibrium reaction. If some of the reactants (irons (III) and thiocyanate) are removed, the system would act to replace them (Le Chatelier's principle) by changing product (iron (III) thiocyanate) back to reactants.	CH12–6, 12–12 Band 2 · Gives the correct visible change. AND · Includes equilibrium/ Le Chatelier's principle. AND · Gives detailed reasoning. 3 --- · Gives the correct visible change. AND · Includes equilibrium/ Le Chatelier's principle. OR · Gives some reasoning. 2 --- · Gives the correct visible change. 1
Question 2.9	
(a) 	CH12–12 Bands 2–3 · Correctly labels E_a forward reaction. AND · Correctly labels E_a reverse reaction. 2 --- · Correctly labels E_a forward reaction. OR · Correctly labels E_a reverse reaction. 1
(b) Activation energy is the minimum energy with which reactants must collide for a reaction to occur.	CH12–7, 12–12 Band 2 · Gives the correct definition. 1

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
(c) The higher the activation energy, the more energy it takes to react. Whichever direction in an equilibrium reaction has the lower activation energy will be favoured, all other things being equal. In the diagram, the activation energy for the forward reaction is less than the activation energy for the reverse reaction. Hence, the position of equilibrium will lie to the right.	CH12–12 Bands 5–6 • Gives the general effect of activation energy on a reaction. AND • Compares activation energy for forward and reverse reactions. AND • Gives the effects on the position of equilibrium in the diagram. 3 --- • Gives the general effect of activation energy on a reaction. AND • Compares activation energy for forward and reverse reactions. OR • Gives the effects on the position of equilibrium in the diagram. 2 --- • Gives some relevant information. 1