OXFORD Study Buddy

QCE CHEMISTRY

UNITS 3 & 4

VOLUME 1

Revision and Exam Guide

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CHAPTER 1 STUDYING FOR SUCCESS

Before you start studying for your QCE Chemistry exams, it's important to set yourself up for success. That's exactly what this chapter is designed to do, so thanks for stopping by!

As soon as it's time to start studying for the external assessment, we recommend that you work through this whole chapter before doing anything else! You might do this at the start of the school year or at the start of your exam study period, but whatever you do, don't skip this chapter; it contains a lot of really important information and tips that might just give you the edge you're looking for.

1.1 OVERVIEW OF QCE CHEMISTRY UNITS 3 & 4

In this section, we will provide a brief overview of how the QCE Chemistry Units 3 & 4 course is structured, list all of the concepts and topics that you will need to learn and understand, and explain how you will be assessed.

1.1.1
Resource: Chemistry General Senior Syllabus

Study tip

The Chemistry General Senior Syllabus sets out all of the information you are expected to learn and provides important information on how you will be assessed.

In this chapter, we have summarised all of the key information you need to know about the external assessment, but the QCAA may update the syllabus from time to time, so it is important that you make sure you are using the most current version!

Make sure you visit the QCAA website and download a copy of the Chemistry General Senior Syllabus and read it carefully before you sit your external assessment. To save your time, we've also included a link to it on your obook assess.

UNDERSTANDING THE QCE CHEMISTRY UNITS 3 & 4 COURSE STRUCTURE

The Chemistry General Senior Syllabus is the most important document supporting the QCE Chemistry course. It sets out all the content – known as subject matter – that you will be expected to learn and provides important information about how you will be assessed.

QCE Chemistry is a course of study consisting of four units (i.e. Units 1 & 2 and Units 3 & 4) taught over two years; but in this revision and exam guide, we will only be focusing on information relating to Units 3 & 4 of the course. The topics you will be learning about in Units 3 & 4 are summarised in Table 1.

HAVING LEGS MADE OF VAPOUR IS A SETBACK FOR SURE... THEY'RE VERY MUCH **MIST!** **OXIDANTS** DO HAPPEN THOUGH, SO I DON'T WANT TO **OVERREACT!**

Course structure for QCE Chemistry Units 3 & 4

Unit 3 Equilibrium, acids and redox reactions	Unit 4 Structure, synthesis and design
Topic 1: Chemical equilibrium systems *Subject matter:* • Chemical equilibrium [3 hours] • Factors that affect equilibrium [2 hours] • Equilibrium constants [4 hours] • Properties of acids and bases [1 hour] • pH scale [2 hours] • Brønsted–Lowry model [2 hours] • Dissociation constants [4 hours] • Acid–base indicators [1 hour] • Volumetric analysis [5 hours] **Topic 2: Oxidation and reduction** *Subject matter:* • Redox reactions [8 hours] • Electrochemical cells [1 hour] • Galvanic cells [5 hours] • Standard electrode potential [2 hours] • Electrolytic cells [4 hours]	**Topic 1: Properties and structure of organic materials** *Subject matter:* • Structure of organic compounds [8 hours] • Physical properties and trends [2 hours] • Organic reactions and reaction pathways [7 hours] • Organic materials: structure and function [5 hours] • Analytical techniques [6 hours] **Topic 2: Chemical synthesis and design** *Subject matter:* • Chemical synthesis [6 hours] • Green chemistry [1 hour] • Macromolecules: polymers, proteins and carbohydrates [7 hours] • Molecular manufacturing [3 hours]

Table 1 Each unit is developed to a notional (i.e. estimated) time of 55 hours of teaching and learning, including assessment. Notional times for each subtopic are also provided.

Modified from *Chemistry General Senior Syllabus 2019 v1.3*

Study tip

The notional hours shown in Table 1 are provided by the QCAA to help teachers with their planning and to give them an estimate of how long to spend teaching the subject matter in each topic.

Notional hours can be a handy way to help you to structure and allocate your revision and preparation time for the external assessment because – as a general rule – there are likely to be more questions on subject matter with more notional hours.

UNDERSTANDING THE QCE CHEMISTRY UNITS 3 & 4 ASSESSMENT STRUCTURE

You will be expected to complete a total of *four* summative assessments in QCE Chemistry Units 3 & 4. Summative assessments are designed to evaluate your understanding of the subject matter and compare your performance against the understanding of students from across the state.

Three of these assessments are internal and one is external, but all will contribute to your Australian Tertiary Admission Rank (ATAR) calculation and to your Queensland Certificate of Education (QCE).

INTERNAL ASSESSMENTS

- Schools will develop **three internal assessments** for QCE Chemistry based on the subject matter described in Units 3 & 4 of the syllabus.
- The three summative internal assessments will be endorsed (i.e. the mark awarded by your teacher will be cross-checked and verified by an independent marker) and the results confirmed by the QCAA.
- As shown in Figure 1, the three internal assessments will contribute **50% to your overall mark**.

CHAPTER 2 REVISION

In this chapter, we provide a clear, concise summary of all examinable content from QCE Chemistry Units 3 & 4 to help you revise and prepare for the external assessment. Everything has been organised by Unit, Topic and Sub-topic in the General Senior Syllabus to help you focus your time and attention where it is needed most.

The revision notes are not designed to replace your teacher or your textbook. Instead, they have been designed to help you gauge your level of understanding and confidence in the subject matter before the exam. You can use them to identify those topics you know inside out and those that still require some extra attention.

The revision notes are also supported by a bunch of handy features, tips and icons to help you get the very best result on the day. Here's an overview of what's covered.

2.1 UNIT 3 TOPIC 1 – CHEMICAL EQUILIBRIUM SYSTEMS

More detail
on pages 44–48
of *Chemistry for Queensland Units 3 & 4*

Questions
on pages 154–189

CHEMICAL EQUILIBRIUM

SUBJECT MATTER

Before the external assessment, you should be able to:

- identify chemical systems that are open (allowing matter and energy to be exchanged with the surroundings) or closed (allow energy, but not matter, to be exchanged with the surroundings)
- identify that physical changes are usually reversible, whereas only some chemical reactions are reversible
- describe and explain, at an atomic and molecular level, the observable changes in chemical reactions and physical changes
- use ⇌ in balanced chemical equations to symbolise equilibrium equations
- identify when dynamic equilibrium is established from the relative concentrations of products and reactants for physical changes and reversible chemical reactions
- explain the reversibility of chemical reactions by considering the activation energies of the forward and reverse reactions
- analyse data, be able to construct graphical representations showing changes in the concentration of reactants and product against time, and identify the position of equilibrium.

CHEMICAL SYSTEMS

KEY CONCEPT

Open systems exchange matter and energy with their surroundings. Closed systems only exchange energy with their surroundings (not matter).

Chemical systems can be open or closed. In an open system, matter and energy can be exchanged with the surroundings. In a closed system, energy can be exchanged with the surroundings, but matter cannot.

CHAPTER 3 PRACTICE QUESTIONS

In this chapter, we provide a range of practice questions for all of the examinable content from QCE Chemistry Units 3 & 4. What a surprise… not! I have a sneaking suspicion the title gave it away!

No fancy tricks here, we just provide more than 250 questions organised by Unit and Topic so you can move effortlessly between revision and practice as you study. We've also grouped the multiple choice and short response questions together so you can prepare for both papers and build your confidence.

Finally, you'll also notice that we've provided a small amount of space under each question for you to jot down your answers or do some working out. In most cases it won't be as much space as you'll be given on the exam itself, but we know you wouldn't want to waste your money on a book full of empty lines. You want lots of questions, so that's what we've given you. If you want to practise under exam conditions, just write your answers on a separate piece of paper.

3.1 UNIT 3 TOPIC 1 – CHEMICAL EQUILIBRIUM SYSTEMS

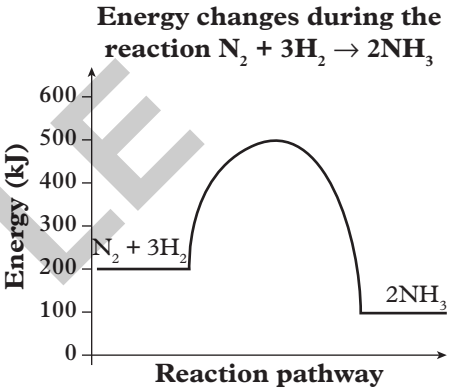
MULTIPLE CHOICE QUESTIONS

Answers
on pages 280–287

QUESTION 1

The activation energy in the diagram is shown to be 300 kJ. What would be the activation energy for the reverse reaction?

(A) 100 kJ
(B) 300 kJ
(C) 400 kJ
(D) 500 kJ



QUESTION 2

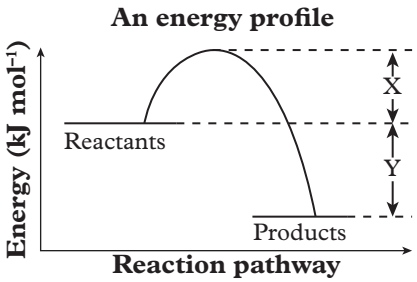
In an open chemical system

(A) energy but not matter is exchanged with the surrounds.
(B) matter but not energy is exchanged with the surrounds.
(C) both matter and energy are exchanged with the surrounds.
(D) neither energy nor matter is exchanged with the surrounds.

QUESTION 3

The energy profile below suggests that

(A) the activation energy of the reverse reaction is (X + Y).
(B) the activation energy for the forward reaction is (X + Y).
(C) ΔH for the reverse reaction is X.
(D) the forward reaction is endothermic.



QUESTION 4

A concentration–time graph is shown for the reaction $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$.

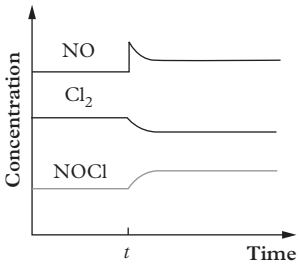
Identify the change at *t* to cause a change in the equilibrium conditions.

(A) A catalyst was added. Temperature and volume remained constant.

(B) Additional NO(g) was added. Temperature and volume remained constant.

(C) The pressure was increased. Temperature remained constant.

(D) The temperature was increased. Volume remained constant.



QUESTION 5

For the equilibrium reaction:

$2NO_2(g) \rightleftharpoons N_2O_4(g)$ $\Delta H = -57$ kJ

what would happen to the concentration of $N_2O_4(g)$ if the temperature was increased?

(A) It would be unchanged because only the reaction rate would be affected.

(B) It would decrease because energy is needed to form more $NO_2(g)$.

(C) It would increase because the reaction is exothermic.

(D) It would decrease because the pressure increases with temperature increase.

QUESTION 6

For a reaction involving a platinum catalyst

$2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g)$ ΔH is positive

the amount of carbon monoxide present in the equilibrium mixture would be

(A) increased by increasing the amount of catalyst.

(B) decreased by increasing the temperature at the same pressure.

(C) increased by decreasing the pressure at the same temperature.

(D) increased by adding oxygen at the same temperature and pressure.

SHORT RESPONSE QUESTIONS

Answers
on pages 287–297

QUESTION 41 (5 marks)

Carbon dioxide in the atmosphere absorbs heat energy, creating a greenhouse effect. It is well known that more carbon dioxide in the atmosphere would result in a temperature increase. The following equation shows the equilibrium relationship between sea water and atmospheric carbon dioxide:

$CO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq) \qquad \Delta H = -15\,kJ$

a) Describe and explain the effect of increased temperature on the solubility of CO_2 gas in sea water. *[3 marks]*

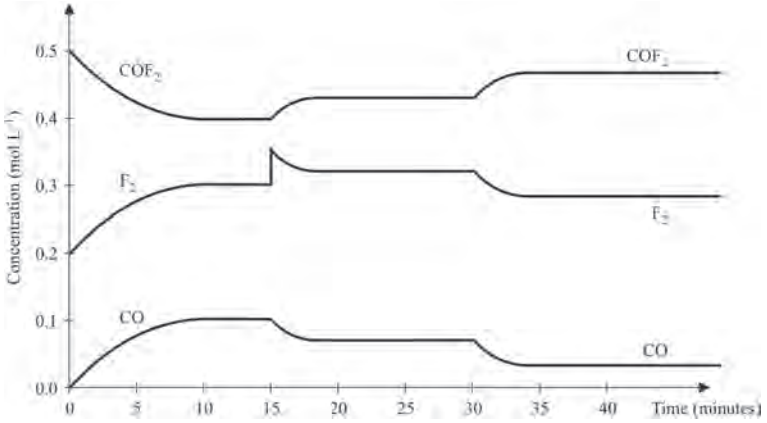
MY MARK /3

b) Explain the effect on the pH of sea water if there is an increase in the amount of carbon dioxide dissolved in water. Assume the temperature remains constant. *[2 marks]*

MY MARK /2

QUESTION 42 (5 marks)

A scientist studying the reaction $CO(g) + F_2(g) \rightleftharpoons COF_2(g)$ measured the concentrations of the gases in a sealed 2 L reaction vessel for a period of time. The results are shown in the graph.



a) State the time the reaction first reached equilibrium. *[1 mark]*

MY MARK /1

b) Describe the change made at t = 15 min. Explain the effect on the concentration of the gases. *[2 marks]*

MY MARK /2

c) At t = 30 min, the temperature of the reaction vessel was decreased. Classify the reaction as exothermic or endothermic. Explain your reasoning. *[2 marks]*

MY MARK /2

QUESTION 43 (7 marks)

The gas carbon oxyfluoride (COF_2) decomposes to the gas carbon tetrafluoride (CF_4) and carbon dioxide.

a) Write a balanced equation for the decomposition reaction. *[1 mark]*

MY MARK /1

b) State the expression for the equilibrium constant. *[1 mark]*

MY MARK /1

CHAPTER 4 OFFICIAL PAST PAPERS

In this chapter, things get serious! It's now time for you to put your revision and practice to the test – literally – by completing the official QCE Chemistry external assessment from 2020.

We recommend you:

- don't look at this chapter until you've finished your revision and completed all of the practice questions in Chapter 3
- complete these papers under exam conditions (i.e. follow the instructions about perusal time and working time, and don't refer to any notes or other materials that will not be allowed during the real exams)
- refer to the answers in Chapter 5 and use the marking advice to self-assess your responses once you've finished.

Remember… these are the QCE Chemistry papers from 2020, so – if you complete them under exam conditions – they are arguably the best indicator of how well you're likely to perform on the day. Good luck!

4.1 EXTERNAL ASSESSMENT 2020: CHEMISTRY PAPER 1

Time allowed

- Perusal time — 10 minutes
- Working time — 90 minutes

General instructions

- Answer all questions in this question and response book.
- QCAA-approved calculator permitted.
- QCAA formula and data book provided.
- Planning paper will not be marked.

Section 1 (20 marks)

- 20 multiple choice questions

Section 2 (40 marks)

- 7 short response questions

Section 1 (20 marks)

MULTIPLE CHOICE QUESTIONS

Answers
on pages 325–327

QUESTION 1

A partly filled water bottle is sealed and left on a bench in a room with a constant temperature. After several minutes, it is noted that the water level in the bottle remains constant. In the water bottle, the rate of evaporation is

(A) less than the rate of condensation.
(B) greater than the rate of condensation.
(C) equal to the rate of condensation and equal to zero.
(D) equal to the rate of condensation but not equal to zero.

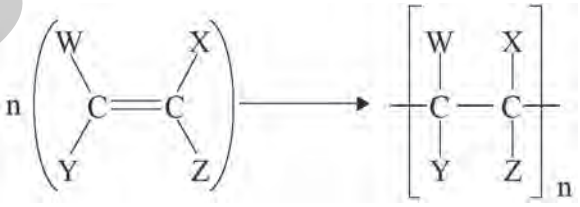
QUESTION 2

$$Mg(s) + 2Ag^{+}(aq) \rightarrow 2Ag(s) + Mg^{2+}(aq)$$

Determine which of the following statements is true for the chemical reaction.

(A) Silver ions are reduced and act as a reducing agent.
(B) Silver ions are oxidised and act as a reducing agent.
(C) Magnesium atoms are reduced and act as a reducing agent.
(D) Magnesium atoms are oxidised and act as a reducing agent.

QUESTION 3



This general chemical equation represents the following type of reaction.

(A) addition
(B) hydrolysis
(C) esterification
(D) condensation

CHAPTER 5 ANSWERS

OMG, another cliff hanger… what on Earth could be in this chapter I wonder?

You guessed it; in this chapter we provide the answers to absolutely everything! Sounds simple, I know, but to get the most out of this chapter, don't just cast an eye over the answers provided and move on.

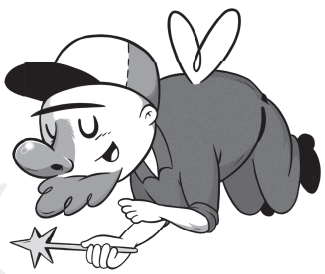
If you really want to increase your chances of excelling on the exam, we recommend you look carefully over each of your answers in Chapters 3 and 4 and compare them with the sample answers in this chapter.

Be sure to use the marking advice that is provided under each sample answer too! You can use it to give yourself a mark for each of your answers and record it in the 'My mark' section.

Following this approach will help you to develop an idea of your strengths and weaknesses, but it will also encourage you to develop good habits! Understanding what exam markers are looking for and how they award marks will make you mindful of how you need to structure your responses in order to maximum your results! Simples!

Notice to students

The answers and marking advice in this chapter are provided for practice purposes only. Unless specifically credited, the QCAA has not written this material and does not endorse the content.

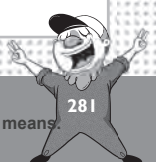


5.1 UNIT 3 TOPIC 1 – CHEMICAL EQUILIBRIUM SYSTEMS

MULTIPLE CHOICE ANSWERS

Question	Correct answer	Explanation
QUESTION 1	C	• C is correct because ammonia becomes the reactant, so the activation energy is measured from ammonia at 100 kJ to the peak at 500 kJ. • A is the ΔH for the reverse reaction. • B and D are both distractors; 300 kJ is mentioned in the question and 500 kJ is the maximum on the graph.
QUESTION 2	C	• C is correct because an open system allows the movement of matter and energy. • A would apply to a closed system. • B and D are both distractors.
QUESTION 3	A	• A is correct because the products become the reactants, so the activation energy is greater because the reverse reaction is endothermic. • B is a distractor because it also includes (X + Y) in the response. • C is incorrect because X is the activation energy of the forward (not reverse) reaction. • D is incorrect because the reverse (not forward) reaction is endothermic.
QUESTION 4	B	• B is correct: the sudden vertical upwards change in concentration shows an increase in NO as it is added to the system. • A is incorrect because adding a catalyst would not cause a sudden increase in NO concentration. Adding a catalyst just makes the system reach equilibrium faster but this system was already at equilibrium. • C is incorrect because increasing pressure would cause a sudden upward change to the concentrations of all substances on the graph, not just a single component. • D is incorrect because increasing temperature would instead cause a shift in the position of equilibrium in the endothermic direction, as indicated by gradual increases or decreases in the concentrations of all substances. Increasing temperature would not cause a sudden change in concentration.

Question	Correct answer	Explanation
QUESTION 5	B	• B is correct because energy is needed for the reverse reaction, which is endothermic. • A is incorrect because, although temperature affects reaction rate, it also affects the position of equilibrium. • C is incorrect because the concentration of $N_2O_4(g)$ would decrease (not increase) if the temperature was increased. Le Châtelier's principle states that when an equilibrium system is heated, the position of equilibrium shifts in the endothermic direction, which is to the left in this example – and the concentration $N_2O_4(g)$ will therefore decrease, not increase. • D is a incorrect because if heating caused a pressure increase, the equilibrium would shift to the right and increase the concentration of $N_2O_4(g)$.
QUESTION 6	C	• C is correct because carbon monoxide is on the side with the greater number of gas molecules, so decreasing the pressure favours the side with more gas molecules. • B is incorrect because increasing temperature would cause the position of equilibrium to shift in the endothermic direction (to the right), causing CO concentration to increase (not decrease). • D is incorrect because adding oxygen would favour the formation of reactants, which would decrease the CO concentrations. • A is incorrect because while adding a catalyst would increase the rate at which the products are formed, it would not change the concentrations of any substances present at equilibrium.
QUESTION 7	A	• A is correct because: (1) removing product from an equilibrium system causes the position of equilibrium to shift to the right, and (2) low pressure favours the side with more gas molecules – also causing the position of equilibrium to shift to the right. • B is incorrect because although low pressure causes the position of equilibrium to shift to the right, the high temperature causes the position of equilibrium to shift to the left because it is an exothermic reaction. • C is incorrect because although low temperature causes the position of equilibrium to shift to the right, high pressure causes the position of equilibrium to shift to the left. • D is incorrect because although the addition of $O_2(g)$ causes the position of equilibrium to shift to the right, high temperature causes the position of equilibrium to shift to the left.
QUESTION 8	C	• C is correct. Heating would favour the endothermic (reverse) reaction and the reactants side has more gaseous molecules than the products side (2 versus 1). • B is incorrect because increasing the temperature of an exothermic equilibrium system causes the equilibrium constant *K* to decrease, not increase. Remember that increasing temperature only increases *K* in an endothermic equilibrium system. • A and D are both incorrect because they both suggest that the products are favoured.



Question	Correct answer	Explanation
QUESTION 38	C	• For multiple choice questions that ask you to perform titration calculations in a single step, use the titration formula: $\frac{c_1 v_1}{\text{ratio}_1} = \frac{c_2 v_2}{\text{ratio}_2}$ Left side: conical flask (NaOH) Right side: burette (HCl) These reactants react in a 1:1 ratio. $\frac{c_1 v_1}{\text{ratio}_1} = \frac{c_2 v_2}{\text{ratio}_2}$ $\frac{c_1 \times 13.49}{1} = \frac{0.2450 \times 25.00}{1}$ $c_1 = \frac{0.2450 \times 25.00}{13.49}$ $= 0.4540$ M
QUESTION 39	D	• D is correct because it is the only compound that can be oxidised by acidified potassium dichromate(VI) solution as it is a secondary alcohol. • A, B and C are incorrect because they cannot be oxidised by acidified potassium dichromate(VI) solution (because they are a tertiary alcohol, a carboxylic acid and a ketone).
QUESTION 40	D	• D is correct. We can find the oxidation number of N in NO_3^- by using algebra: Let x represent the oxidation number of N in NO_3^-. Sum of all oxidation numbers = charge of ion $x + 3(-2) = -1$ $x = 5$

• *1 mark* for each correct multiple choice answer

SHORT RESPONSE ANSWERS

QUESTION 41 (5 marks)

a) Less $CO_2(g)$ would dissolve.
At higher water temperatures, the reverse reaction would be favoured to establish a new equilibrium according to Le Châtelier's principle. The absorption of $CO_2(g)$ is exothermic as shown by the negative enthalpy change value (ΔH).
- *1 mark* for description of effect
- *1 mark* for describing effect on the equilibrium
- *1 mark* for reason, using enthalpy value

b) If more $CO_2(g)$ dissolves, the equilibrium is driven forward, producing more H^+ ions, so the pH will decrease.
- *1 mark* for correct description of effect on pH
- *1 mark* for providing reason

QUESTION 42 (5 marks)

a) First reaches equilibrium at approximately 10 min
- *1 mark* for correctly identifying the time

b) $F_2(g)$ is added to the system.
Addition of a reactant will drive the reaction to favour the products (forward). $[F_2]$ and [CO] will decrease and $[COCF_2]$ will increase.
- *1 mark* for recognising reaction will proceed forwards
- *1 mark* for describing impact on concentration

c) When the temperature is decreased, the reaction is driven forward because $[F_2]$ and [CO] decrease and $[COF_2]$ increases; this indicates that it is an exothermic reaction as more products are formed when the temperature is decreased.
- *1 mark* for explaining change in equilibrium direction
- *1 mark* for classifying reaction as exothermic

QUESTION 43 (7 marks)

a) $2COF_2(g) \rightleftharpoons CF_4(g) + CO_2(g)$

- *1 mark* for giving a balanced equation

b) $K = \dfrac{[CF_4]\,[CO_2]}{[COF_2]^2}$

- *1 mark* for correct expression

c) i)

	$2COF_2(g) \rightleftharpoons$	$CF_4(g)$ +	$CO_2(g)$
R	2	1	1
I	$\frac{2.0\text{ mol}}{10\text{ L}} = 0.2$	0	0
C	$0.2 - (0.8 \times 0.2)$	$\frac{0.16}{2}$	$\frac{0.16}{2}$
E	0.04	0.08	0.08

- *1 mark* for correct equilibrium concentrations

ii) $K = \dfrac{[CF_4]\,[CO_2]}{[COF_2]^2}$

$= \dfrac{(0.08)\,(0.08)}{(0.04)^2}$

$= 4$

- *1 mark* for equilibrium constant (K) value

d) There would be no effect on the equilibrium constant.

- *1 mark* for stating effect

e) The reaction is exothermic; according to Le Châtelier's principle an increase in temperature will favour the endothermic reaction which is the reverse of the reaction in part a. The amount and fraction of COF_2 would increase as it is the reactant.

- *1 mark* for stating reaction type
- *1 mark* for providing reason

QUESTION 44 (9 marks)

a) $K_c = \dfrac{[CH_3OH]}{[CO]\,[H_2]^2}$

- *1 mark* for correctly stating equilibrium expression

b) $K_c = \dfrac{4.17 \times 10^{-8}}{(3.76 \times 10^{-3})\,(4.3 \times 10^{-3})^2} = 0.60$

- *1 mark* for correct value

c) The small K_c value means that the product, methanol, is not formed readily.

- *1 mark* for correct inference

d) Since the temperature has not changed, $K_c = 0.60$ so

$0.60 = \dfrac{[CH_3OH(g)]}{(7.52 \times 10^{-3})\,(8.6 \times 10^{-3})^2}$

Rearrange the equation to solve for

$[CH_3OH] = 3.34 \times 10^{-7}$ M

- *1 mark* for writing correct calculation
- *1 mark* for finding new concentration $[CH_3OH]$

e) In an exothermic reaction, heat is generated by the reaction; according to Le Châtelier's principle, the reverse reaction will be favoured (endothermic) to decrease the effect of the change. This will result in a decrease in methanol yield.

- *1 mark* for direction
- *1 mark* for prediction (responding to cognitive verb)

f) The methanol yield would decrease. According to Le Châtelier's principle, the side of the reaction with more moles will be favoured when the pressure decreases. Since there are more gaseous reactants (3 moles) than gaseous products (1 mole), a decrease in pressure will decrease methanol yield as the equilibrium shifts to the left.

- *1 mark* for correct concentration change
- *1 mark* for providing reason

QUESTION 45 (2 marks)

According to Le Châtelier's principle, an increase in temperature favours the endothermic reaction. When temperature increases, K decreases, which indicates that the reverse reaction has been favoured by decreasing the temperature. This tells us that the reverse reaction is endothermic, and the forward reaction is therefore exothermic.

- *1 mark* for correct response
- *1 mark* for evidence of reasoning (cognitive verb is *deduce*)

QUESTION 46 (3 marks)

a) No change. There are equal numbers of moles of gaseous reactants and products so changing the pressure would have no effect.

- *1 mark* for correct answer. Reasons required in response (cognitive verb is *explain*).

APPENDIX

CHEMISTRY

FORMULA AND DATA BOOK

The QCAA has developed a formula and data book that will be provided for you to use during both examination papers. It provides a selection of useful formulas, conversion tables, the periodic table of elements and a range of other data and information for you to refer to during the exam.

We want you to have everything you need in the one spot so that you can study effectively whenever and wherever you are – on the bus, in the bath… wherever! For that reason, we've included the Formula and data book here, too. Shucks, that's what buddies are for!

Formulas

Processing of data
Absolute uncertainty of the mean $\Delta\bar{x} = \pm\frac{(x_{max} - x_{min})}{2}$
Percentage uncertainty (%) $= \frac{\text{absolute uncertainty}}{\text{measurement}} \times \frac{100}{1}$
Percentage error (%) $= \left\lvert\frac{\text{measured value} - \text{true value}}{\text{true value}}\right\rvert \times 100$

Chemical reactions — reactants, products and energy change
$\triangle H = H_{(\text{products})} - H_{(\text{reactants})}$
$\triangle H = \Sigma(\text{bonds broken}) - \Sigma(\text{bonds formed})$
$Q = mc\Delta T$
Percentage yield (%) $= \frac{\text{experimental yield}}{\text{theoretical yield}} \times \frac{100}{1}$

Aqueous solutions and acidity
Molarity $= \frac{\text{moles of solute } (n)}{\text{volume of solution } (V)}$

Chemical equilibrium systems
$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$ for the reaction: aA + bB ⇌ cC + dD
$K_w = [H^+][OH^-]$
$pH = -\log_{10}[H^+]$
$pOH = -\log_{10}[OH^-]$
$K_w = K_a \times K_b$
$K_a = \frac{[H_3O^+][A^-]}{[HA]}$
$K_b = \frac{[BH^+][OH^-]}{[B]}$

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Physical constants and unit conversions

Physical constants and unit conversions	
Absolute zero	0 K = –273 °C
Atomic mass unit	1 amu = 1.66×10^{-27} kg
Avogadro's constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
Ideal gas constant	$R = 8.31$ J mol^{-1} K^{-1}
Ionic product constant for water (at 298 K)	$K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6}
Molar volume of an ideal gas (at STP)	2.27×10^{-2} m^3 mol^{-1} = 22.7 dm^3 mol^{-1}
Specific heat capacity of water (at 298 K)	$c_w = 4.18$ J g^{-1} K^{-1}
Standard temperature and pressure (STP)	273 K and 100 kPa
Volume and capacity conversions	1 dm^3 = 1×10^{-3} m^3 = 1×10^3 cm^3 = 1 L

List of elements

Name	Atomic no.	Symbol
Hydrogen	1	H
Helium	2	He
Lithium	3	Li
Beryllium	4	Be
Boron	5	B
Carbon	6	C
Nitrogen	7	N
Oxygen	8	O
Fluorine	9	F
Neon	10	Ne
Sodium	11	Na
Magnesium	12	Mg
Aluminium	13	Al
Silicon	14	Si
Phosphorus	15	P
Sulfur	16	S
Chlorine	17	Cl
Argon	18	Ar
Potassium	19	K
Calcium	20	Ca
Scandium	21	Sc
Titanium	22	Ti
Vanadium	23	V
Chromium	24	Cr
Manganese	25	Mn
Iron	26	Fe
Cobalt	27	Co
Nickel	28	Ni
Copper	29	Cu
Zinc	30	Zn

Name	Atomic no.	Symbol
Gallium	31	Ga
Germanium	32	Ge
Arsenic	33	As
Selenium	34	Se
Bromine	35	Br
Krypton	36	Kr
Rubidium	37	Rb
Strontium	38	Sr
Yttrium	39	Y
Zirconium	40	Zr
Niobium	41	Nb
Molybdenum	42	Mo
Technetium	43	Tc
Ruthenium	44	Ru
Rhodium	45	Rh
Palladium	46	Pd
Silver	47	Ag
Cadmium	48	Cd
Indium	49	In
Tin	50	Sn
Antimony	51	Sb
Tellurium	52	Te
Iodine	53	I
Xenon	54	Xe
Cesium	55	Cs
Barium	56	Ba
Lanthanum	57	La
Cerium	58	Ce
Praseodymium	59	Pr
Neodymium	60	Nd

Name	Atomic no.	Symbol
Promethium	61	Pm
Samarium	62	Sm
Europium	63	Eu
Gadolinium	64	Gd
Terbium	65	Tb
Dysprosium	66	Dy
Holmium	67	Ho
Erbium	68	Er
Thulium	69	Tm
Ytterbium	70	Yb
Lutetium	71	Lu
Hafnium	72	Hf
Tantalum	73	Ta
Tungsten	74	W
Rhenium	75	Re
Osmium	76	Os
Iridium	77	Ir
Platinum	78	Pt
Gold	79	Au
Mercury	80	Hg
Thallium	81	Tl
Lead	82	Pb
Bismuth	83	Bi
Polonium	84	Po
Astatine	85	At
Radon	86	Rn
Francium	87	Fr
Radium	88	Ra
Actinium	89	Ac
Thorium	90	Th

Name	Atomic no.	Symbol
Protactinium	91	Pa
Uranium	92	U
Neptunium	93	Np
Plutonium	94	Pu
Americium	95	Am
Curium	96	Cm
Berkelium	97	Bk
Californium	98	Cf
Einsteinium	99	Es
Fermium	100	Fm
Mendelevium	101	Md
Nobelium	102	No
Lawrencium	103	Lr
Rutherfordium	104	Rf
Dubnium	105	Db
Seaborgium	106	Sg
Bohrium	107	Bh
Hassium	108	Hs
Meitnerium	109	Mt
Darmstadtium	110	Ds
Roentgenium	111	Rg
Copernicium	112	Cn
Nihonium	113	Nh
Flerovium	114	Fl
Moscovium	115	Mc
Livermorium	116	Lv
Tennessine	117	Ts
Oganesson	118	Og

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