華中國際學校
Hwa Chong INTERNATIONAL SCHOOL
A MEMBER OF THE HWA CHONG FAMILY OF SCHOOLS

PRELIMINARY EXAMINATION
International Baccalaureate 2

Chemistry
Higher level
Paper 3

Wednesday 4 September 2019

1 hour 15 minutes

Candidate name	
Candidate session number	Class

Instructions to candidates

- Write your candidate name and session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[45 marks]**.

Section A	Questions
Answer all questions.	1

Section B	Questions
Answer all of the questions from the option.	
Option D – Medicinal chemistry	2–5

For Examiner's Use	
Section A	/ 15
Section B	/ 30
Total	/ 45

Section A

Answer **all** questions. Write your answers in the boxes provided.

1. Rhubarb, spinach and beet are example of plants with high oxalate–content foods. Oxalic acid, $H_2C_2O_4$ and its salts occur as end–products of metabolism in these plants. Consuming these plants may have some adverse effects in our bodies. The oxalate ion ($C_2O_4^{2-}$) binds with primarily calcium and can cause stone formation in the urinary tract.

However to reduce the oxalate content, soaking these plants in **hot water** may possibly reduce the oxalate content by action of leaching. The solution containing these ions can then be quantitatively determined. Methods like redox titration with potassium permanganate, $KMnO_4$, can be used to determine the amount of oxalate ion in plants. The redox reaction between oxalate and permanganate ion is shown as below:

$$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$$

(a) (i) Suggest a plausible research question for the study mentioned above. [1]

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(ii) Identify two controlled variables in the experiment above. [2]

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(This question continues on the following page)

(Question 1 continued)

(b) The standard solution of standard $KMnO_4$ was prepared fresh and kept in a dark bottle and the burette and flask were covered with aluminium foil. This was to minimise the decomposition of $KMnO_4$ by sunlight.

Comment how this can affect the accuracy of the experiment and explain how the volume of titre could be affected **if one fails to do so**. [2]

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(c) After soaking the spinach in hot water for a period of time, the solution containing oxalate ions (extracted from 500.0 g of spinach) was transferred to a 250.0 cm^3 standard volumetric flask and the solution was made up to 250.0 cm^3 using tap water.
White solid appeared and was observed to settle at the bottom of the flask.
25.0 cm^3 of standard oxalate solution was then pipetted and titrated against 0.001 mol dm^{-3} of $KMnO_4$.
The average titre of 23.50 cm^3 of $KMnO_4$ was determined.

(i) Calculate the amount of oxalate ions in 25.0cm^3 of oxalate ion. [2]

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(This question continues on the following page)

(Question 1 continued)

(ii) State one assumption in your calculation and hence determine the concentration (ppm) of oxalate ions ($C_2O_4^{2-}$) in 500.0 g of spinach. [2]

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(iii) The solubilities of some oxalate salts are given below.

Oxalate salt	**Concentration (g dm^{-3})**
MgC_2O_4	12.5
$Na_2C_2O_4$	26.9
CaC_2O_4	0.0067g

Justify the identity of the white solid formed in (c). [2]

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(iv) The formation of the white solid is a systematic limitation in this experiment. Suggest an improvement to overcome this. [1]

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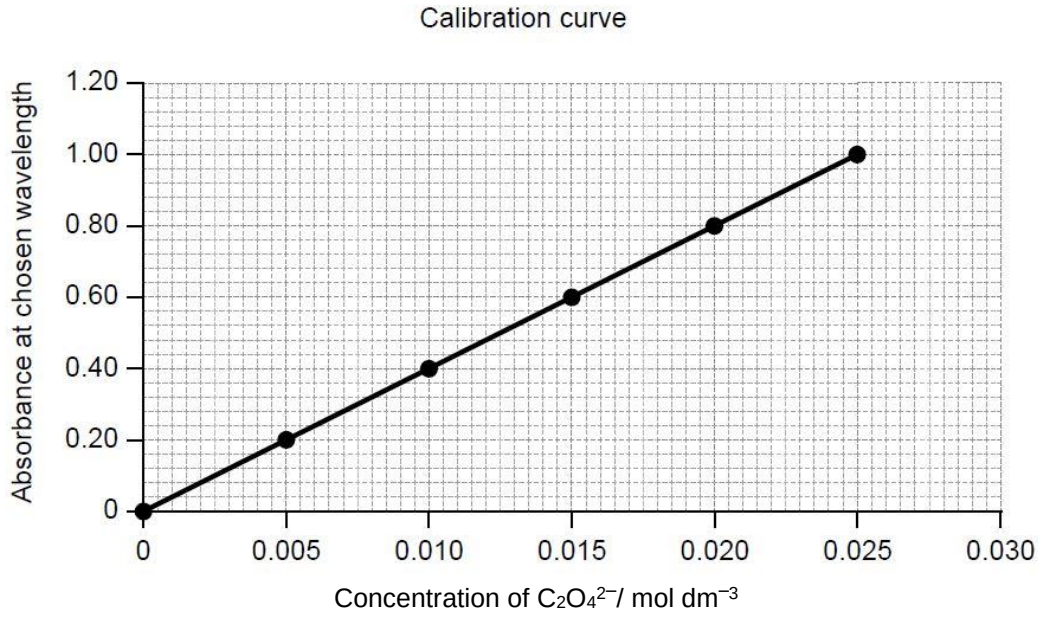
(This question continues on the following page)

(Question 1 continued)

(d) In another experiment, oxalate ion was complexed with the iron (II) ion to form a yellow solution. The concentration of oxalate ions in the resulting solution is then determined from a calibration curve, which is plotted by measuring the light absorbance of standard solutions.



(i) Deduce the relationship between absorbance and concentration. [1]

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(ii) By interpolation of the graph above, determine the concentration of oxalate ion, $C_2O_4^{2-}$, when the absorbance measured is 0.08 A. [2]

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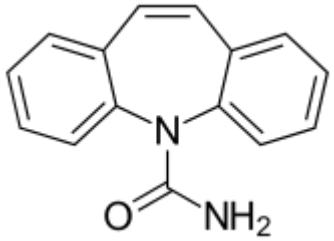
Section B

Answer **all** of the questions. Write your answers in the boxes provided.

Option D – Medicinal chemistry

2. Carbamazepine, $C_{15}H_{17}N_2O$, sold under the trade name Tegretol, is used primarily in the treatment of epilepsy and neuropathic pain. It is classified as a *narrow therapeutic index drug*. Common adverse effects include drowsiness, dizziness, headaches and migraines, motor coordination impairment, nausea, vomiting, and/or constipation.
Synergistic effects with alcohol while taking carbamazepine may lead to enhanced depression of the central nervous system.



Carbamazepine

(a) Deduce the IHD of Carbamazepine. [1]

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(b) Comment on the solubility of the drug. [1]

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(Option D continues on the following page)

(Option D, question 2 continued)

(c) (i) Carbamazepine is tested by injection into mice to establish its LD_{50} and ED_{50} values. Distinguish between the two terms. [2]

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(ii) State the significance of the term "therapeutic index" in drug administration. [1]

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(d) Describe the term "synergistic effect". [1]

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(e) State **one** advantage of combinatorial chemistry in drug synthesis. [1]

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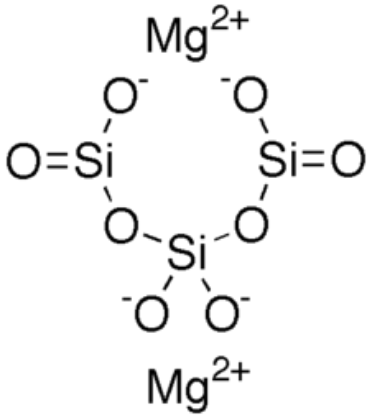
3. Magnesium trisilicate is used as an antacid to treat indigestion and heartburns.



It reacts with hydrochloric acid in the stomach to form a soluble chloride salt, along with a colloidal mixture of silicic acid, H_2SiO_3, and silicon dioxide.

(a) Construct the balanced chemical equation for the reaction of magnesium trisilicate with HCl. [1]

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(b) Magnesium hydroxide is used as an antacid, however sodium hydroxide is not recommended for the treatment of stomach acidity.
Suggest why sodium hydroxide is not used in treating acidity of the stomach. [1]

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(c) Evaluate whether 0.1 mol of magnesium trisilicate is a more or less effective antacid as compared to 0.1 mol of aluminium hydroxide. [2]

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(Option D continues on the following page)

(Option D, question 3 continued)

(d) Explain the action of Ranitidine (section 37 in data booklet) in controlling gastric acidity. [2]

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(e) Aspirin shows two absorptions in the region 1700–1750 cm^{-1} in its infrared spectrum. These two absorptions are due to the two different carbonyl groups (C=O). Explain why they do not both occur at exactly the same frequency. [1]

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4. (a) Influenza A, also known as **H1N1**, is a respiratory disease caused by the *Alphainfluenzavirus*. It was responsible for the pandemic in 2009. [1]
State what do **H** and **N** stand for.

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(b) Refer to the structure of Zanamivir in section 37 of the data booklet.

(i) Identify the number of chiral centres in the molecule. [1]

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(Option D continues on the following page)

(Option D, question 4 continued)

(ii) Describe the antiviral action of Zanamivir. [1]

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(c) AIDS is treated using antiretroviral therapy which involves treatment with a mixture of antiviral drugs.
Discuss **two** difficulties, other than economic and socio–cultural issues, associated with the treatment of AIDS. [2]

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(d) Explain why supercritical carbon dioxide has mainly replaced organic solvents to sustainably extract essential oils, from plant material. [1]

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(Option D continues on the following page)

5. (a) Taxol is an anticancer drug with a complex structure with multiple chiral carbon centres (section 37 of data booklet).

(i) State the action of Taxol in chemotherapy. [1]

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(ii) Taxol can be made by *semi–synthesis*. Explain the meaning of this term. [1]

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(b) Describe how chiral auxiliaries can be used to synthesise only the desired enantiomeric form of a drug from a non–chiral compound. [3]

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(Option D continues on the following page)

(Option D, question 5 continued)

(c) Outline how the waste of technetium–99m, a low level metastable radionucleotide, might be treated. [1]

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(d) Technetium–99m is generated in a hospital from molybdenum–99.

(i) Using section 6 of the data booklet, deduce the nuclear equation for the radioactive decay of technetium–99, when it emits beta radiation. [1]

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(ii) A patient is given 0.05 mg of technetium–99m, which has a half–life of 6.0 hours. Calculate how much time would elapse until the radioactive isotope decays to 6.3×10^{-3} mg. You may refer to section 1 and 2 of the data booklet. [2]

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(e) Methyltestosterone is a banned synthetic steroid, which may be used illegally by athletes to enhance performance.
Suggest the analytical method(s) that can be used to detect the presence of these compounds in the urine sample of an athlete. [1]

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