Candidate Full Name	Candidate Number

Anglo-Chinese School
(Independent)

YEAR 6 PRELIMINARY EXAMINATION 2020

INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME

CHEMISTRY HIGHER LEVEL
Paper 3

Tuesday **15 September 2020** **1 hours 15 minutes**

INSTRUCTIONS TO CANDIDATES

- Write your **candidate number in the box above**.
- Do not open this examination paper until instructed to do so.
- Answer all questions
- A calculator is required for this paper.
- A copy of the Chemistry Data Booklet is required for this paper.
- Write your answers in the boxes provided.
- The maximum marks for this examination paper is **45 marks**.

For examiner's use	
Section A	
Qn 1	/7
Qn 2	/8
Section B	
Qn 3	/6
Qn 4	/6
Qn 5	/8
Qn 6	/10
Total	/45

This question paper consists of 14 printed pages including this cover page.

Section A

Answer **all** questions. Answers must be written in the answer boxes provided.

1. "Lethal Dose", LD, is a means of measuring toxicity. LD_{50} is the amount of a material which causes the death of 50% of a group of test animals. Its value is expressed as the mass of a chemical administered per kg body mass of a test animal.

"Lethal Concentration", LC, is another means of measuring toxicity. The value of LC_{50} is the concentration of a chemical in the air that kills 50% of the test animals during the observation period.

The table below shows the values for the LD_{50} and LC_{50} along with the toxicity ratings.

Toxicity rating	Commonly used term	LD_{50}: Oral ($mg\ kg^{-1}$)	LC_{50}: Inhalation (ppm)
1	Extremely Toxic	1 or less	10 or less
2	Highly Toxic	1 – 50	10 – 100
3	Moderately Toxic	50 – 500	100 – 1000
4	Slightly Toxic	500 – 5000	1000 – 10 000
5	Practically Non-toxic	5000 – 15 000	10 000 – 100 000
6	Relatively Harmless	15 000 or more	100 000 or more

(a) 9.90×10^{-4} mol of a toxic compound, C_4H_5NO, was found to cause death in 50% of test animals weighing 1 kg.

Calculate the LD_{50} of the compound and state its toxicity rating. [2]

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(Question 1 continued)

(b) Phosphine, PH_3, is a gas widely used in the semiconductor industries as a dopant and a precursor for the deposition of compound semiconductors.

For safety considerations, the permissible limits of phosphine must not exceed $\frac{1}{10}$ of the LC_{50} value expressed in terms of ppm.

When expressing the concentration of a small quantity of gas, parts per million (ppm) can be used. The unit 'ppm' is usually used for volume of gases and is expressed as shown in the equation below:

$$\text{The concentration of gas (in ppm)} = \frac{\text{volume of gas}}{\text{volume of air}} \times 10^6$$

(i) Given that the LC_{50} for phosphine is 55 mg m^{-3} at standard temperature and pressure, convert the LC_{50} to ppm and determine its toxicity rating. [3]

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(Question 1 continued)

(ii) A factory in the semiconductor industries attempts to assess the polluting rating based on the air emitted from its factory daily.
The semiconductor factory releases 24.0 dm^3 of phosphine in a day. Using your value in (b)(i), determine the minimum volume of air emitted that will allow the volume of phosphine to be within permissible limits.
(You may assume that the LC_{50} value is 30.0 ppm if you did not obtain an answer in (b)(i).)

[2]

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2. Calcium iodate(V), $Ca(IO_3)_2$, is sparingly soluble in water. It has a solubility of approximately 4.6 g dm^{-3} at 25 °C. A student would like to investigate the effect of increasing temperature on the solubility of the salt. He decided to measure the solubility of $Ca(IO_3)_2$ using gravimetric analysis.

The steps of the experiment were outlined as follows.

Step 1: Dissolve 1.0 g of calcium iodate(V) salt into a 100 cm^3 distilled water at room temperature. Filter the resulting mixture immediately to separate the undissolved solid from the filtrate.

Step 2: Pipette 25 cm^3 of the filtrate into a petri dish. Place the petri dish into a drying oven to evaporate the water at 100 ^oC.

Step 3: Remove the petri dish and its content from the oven when the water is completely evaporated. Record the mass of the petri dish and its content.

Step 4: Repeat steps 1 to 3 to determine the solubility of the salt at four other temperatures, namely 35, 45, 55 and 65 ^oC using a Bunsen burner.

(a) The solubility of calcium iodate(V) is represented by the following chemical equation.

$$Ca(IO_3)_2\,(s) \rightleftharpoons Ca^{2+}\,(aq) + 2IO_3^-\,(aq) \qquad \Delta H_{sol} > 0$$

Predict and explain how the solubility of calcium iodate(V) in water changes as the temperature is increased. [3]

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(Question 2 continued)

(b) Suggest **two** sources of errors in the experiment, assuming that there was no human error and the balance was accurate. Then suggest an improvement for each error. [4]

Error 1:

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Suggestion for improvement:

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Error 2:

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Suggestion for improvement:

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(c) Suggest **another** method which can be used to determine the solubility of calcium iodate(V). [1]

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Section B

Option D – Medicinal chemistry

Answer **all** questions. Answers must be written in the answer boxes provided.

3. In 1897, while working for pharmaceutical company Bayer, German chemist Felix Hoffmann found that adding an acetyl group to salicylic acid reduced its irritant properties. As a result, aspirin was synthesised and Bayer patented the process.

(a) A sample of aspirin crystals was prepared from salicylic acid in the laboratory. The product was extracted from the reaction mixture, and the sample was dried.

(i) Suggest how infrared (IR) spectroscopy can be used to distinguish aspirin from salicylic acid using data from section 26 of the data booklet. [2]

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(ii) Suggest, giving a reason, **one** step that can be carried out during the synthesis to remove salicylic acid present in the aspirin crystals. [2]

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(Question 3 continued)

(b) Aspirin is only slightly soluble in water. Refer to section 37 of the data booklet for the structure of aspirin and describe, using a chemical equation, how aspirin can be more water-soluble. [2]

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4. Excess acid in the stomach can cause the breakdown of the stomach lining.

(a) Outline how ranitidine (Zantac) inhibits stomach acid production. [1]

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(b) Some medicine formulations contain a buffer to improve the stability of the drug. Calculate the mass of sodium ethanoate solid to be added to 100 cm^3 of 0.10 mol dm^{-3} of ethanoic acid to prepare a pH 4.2 buffer solution using data from section 21 of the data booklet.
The M_r of sodium ethanoate is 82.03 g mol^{-1}. [3]

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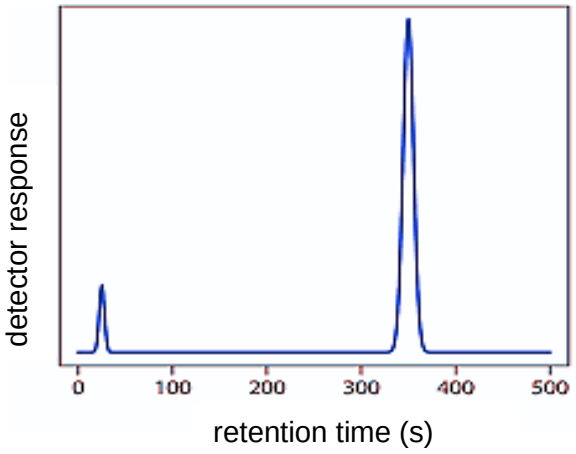
(Question 4 continued)

(c) Drug analysis includes the aspects of identifying novel drugs, assessing their affinities and specificity, characterising their molecular structures. The analyses of drugs and metabolites in biological fluids, particularly plasma, serum or urine is one of the most demanding but one of the most common uses of high-performance of liquid chromatography.

In a chromatographic separation, explain how information from the chromatogram below can be used for the **qualitative** identification of a drug. [2]



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5. Azidothymidine (AZT), is an antiretroviral medication used to prevent and treat HIV/AIDS. It is generally recommended for use with other antiretrovirals. It works by inhibiting the enzyme reverse transcriptase that HIV uses to make DNA and therefore decreases the replication of the virus.

(a) Discuss **two** challenges that made treating patients with HIV difficult. [2]

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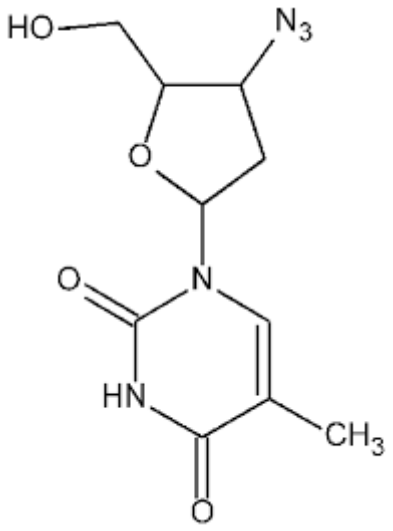
(b) Identify **two** functional groups in the structure of Azidothymidine (AZT). [1]



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(c) Suggest **one** reason why intravenous infusion is used to administer Azidothymidine (AZT). [1]

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(Question 5 continued)

(d) Polar solvents such as acetone and methanol are used extensively in the Azidothymidine (AZT) synthesis and purification process.

Suggest **one** green solvent that can be used in the synthesis and purification process. [1]

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(e) Morphine is used to treat severe pain felt by patients after an operation or a serious injury.

(i) Explain how strong analgesic drugs like morphine work to relieve pain. [2]

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(ii) The Therapeutic Index or T.I. is used as a measure of how safe a medicine is. Morphine has a therapeutic index of 70:1, while Digoxin, a cardiac glycoside has a therapeutic index of approximately 2:1.

Using the information given, comment on the risks when prescribing Morphine and Digoxin. [1]

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6. Nuclear medicine uses small amounts of radioisotopes to diagnose and treat some diseases. In the past, diagnosing internal problems often needed surgery, but nuclear medicine makes this unnecessary.

(a) A very effective role for radioisotopes in nuclear medicine is the use of short-lived positron emitters such as ^{18}F in a process known as Positron Emission Tomography (PET). After diagnosis, and when treatment starts, PET can show how well the treatment is working.

(i) Given that fluorine-18 has a half-life of 6.70×10^{-6} s, calculate the mass of fluorine-18 remaining after 3.50×10^{-6} s from a sample containing 5.00 g of fluorine-18. [2]

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(ii) Radiotherapy is a cancer treatment that uses high doses of radiation to kill cancer cells and shrink tumours. State **two** common side effects of radiotherapy. [2]

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(Question 6 continued)

(b) Chemotherapy is equated with the use of anticancer drugs; it is used in conjunction with nuclear medicine to treat some cancers.

(i) Name **one** type of cancer that is commonly treated by Taxol. [1]

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(ii) Identify and describe **two** challenges faced during the natural synthesis of Taxol. [2]

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(iii) Describe how the use of chiral auxiliaries supports the chemical synthesis of enantiomerically pure drugs. [3]

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End of Paper