Anglo-Chinese School
(Independent)

Year 6 Preliminary Examination 2018
INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME
CHEMISTRY HIGHER LEVEL

PAPER 3

Thursday 13th September 2018 1 hour 15 minutes

Candidate Session Number

0	0	2	3	2	9				

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Write your **candidate session number in the box above**.
- A calculator is required for this paper.
- A copy of the Chemistry Data Booklet is required for this paper.
- Answer **all** questions from Section A and Section B in the boxes provided.
- If you use additional sheets of paper for your answer, attach them to the booklet. Indicate the question number clearly on these sheets.
- The maximum mark for this examination paper is **[45 marks]**.

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

This question paper consists of 12 printed pages including this cover page.

Section A

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

1. The overall PSI (Pollutant Standard Index) is an air quality indicator that is based on five pollutants namely particulate matter (PM10), sulfur dioxide, carbon monoxide, ozone and nitrogen dioxide.

To calculate the overall PSI for an area, the **PSI pollutant value** of each pollutant is firstly calculated using the formula and table of **P** and **C** values given below.

n	**P**	**C**				
		PM10 ($\mu g\ m^{-3}$)	SO_2 ($\mu g\ m^{-3}$)	CO ($mg\ m^{-3}$)	Ozone ($\mu g\ m^{-3}$)	NO_2 ($\mu g\ m^{-3}$)
1	50	50	80	5	118	-
2	100	150	365	10	157	-
3	200	350	800	17	235	1130
4	300	420	1600	34	785	2260
5	400	500	2100	46	980	3000
6	500	600	2620	58	1180	3750

$$\textbf{PSI pollutant value} = \left[\frac{\mathbf{P_{(n+1)} - P_{(n)}}}{\mathbf{C_{(n+1)} - C_{(n)}}} \times \left(\text{concentration of each pollutant measured} - \mathbf{C_{(n)}}\right)\right] + \mathbf{P_{(n)}}$$

Given the concentration of each pollutant (with units as stated in the table above), where $\mathbf{C_{(n+1)}}$ > concentration of each pollutant measured > $\mathbf{C_n}$.

The highest **PSI pollutant value** calculated for the 5 pollutants will be taken as the overall PSI for that area.

In Singapore, the 24-hr overall PSI is used by the National Environmental Agency (NEA) to provide health advisory.

24-hr overall PSI	**Healthy Persons**	**Elderly, Pregnant women & children**	**Persons with chronic lung disease, heart disease and stroke**
<100	Normal activities		
101-200	Minimise prolonged or strenuous outdoor physical exertion.	Minimise prolonged outdoor activity.	Avoid all outdoor activities. If outdoor activity is unavoidable, wear N95 mask.
201-300	Avoid all outdoor activities. If outdoor activity is unavoidable, wear N95 mask.	Avoid all outdoor activities. If outdoor activity is unavoidable, wear N95 mask (for adults).	
>300	Minimise all outdoor exposure. If outdoor activity is unavoidable, wear N95 mask.		

(This question continues on the following page)

(Question 1 continued)

(a) (i) In a 1 m^3 sample of air, the mass of PM10 and carbon monoxide were measured to be 320 μg and 20 *mg* respectively. Calculate the PSI pollutant values for each of the above pollutants. [2]

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(ii) Given that the PSI pollutant values of sulfur dioxide, ozone and nitrogen dioxide are 150, 112 and 133 respectively for the same sample of air, use these values and your answers in (a)(i) to deduce the overall PSI for that area. [1]

(If you did not obtain answers to (a)(i), use values of 200 and 300 for the PSI pollutant values for PM10 and CO respectively, although these are not the correct answers.)

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(iii) Using answer in (a)(ii), what advice would you give to an incoming visitor to Singapore? [1]

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(This question continues on the following page)

(Question 1 continued)

(b) Some countries have set limits for particulates in the air. For instance, the European Union (EU) has a limit of 180 μg m^{-3} for PM10. Cities that violate this daily limit will face a hefty financial penalty that is calculated with consideration of many factors such as the severity the violation has on the ecosystem, duration of non-compliance and the country's GDP.

(i) 1 m^3 sample of air from the English city of Manchester contained 2×10^{-5} % by mass of PM10. Calculate the concentration of PM10, measured in μg m^{-3}, in the sample. [1]
(Given that density of air is 1 kg m^{-3})

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(ii) Hence, deduce whether the English city of Manchester will be faced with any financial penalty by the EU. [1]

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(Question 1 continued)

(c) The amount of sulfur dioxide in a sample of air can be determined by first bubbling the air through a solution of sodium iodate, $NaIO_3$, to produce iodine and sodium sulfate.

(i) Write an ionic equation for the reaction between sulfur dioxide and sodium iodate. [2]

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(ii) 1 m^3 sample of air was bubbled through a solution of sodium iodate and the resulting solution was neutralized by adding 10.0 cm^3 of 0.005 mol dm^{-3} sodium hydroxide solution. Calculate the mass of SO_2 in the sample of air. [2]

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2. In the 19th century, iodine was industrially produced from kelp, a large seaweed. Combustion of kelp converts the organic substances to ash, and sodium iodide is obtained. In the laboratory, a similar process can be done according to the following procedure.

1. Fill a large crucible on a tripod with the seaweed. Heat with a strong Bunsen flame until all the seaweed has been converted to ash.
2. Boil the ash with about 20.0 cm^3 of purified water in a beaker, and filter while hot. Collect the filtrate in a second beaker and allow it to cool.
3. Add about 2.0 cm^3 of dilute sulfuric acid to the filtrate, followed by excess hydrogen peroxide solution.
4. Transfer the mixture to a separating funnel and add 20 cm^3 of a suitable organic solvent. Stopper the separating funnel and shake vigorously for about 30 s. With the separating funnel inverted, release any pressure that has built up by opening the tap briefly.
5. Clamp the funnel and allow the layers to separate.
6. Run off the aqueous layer into a 250 cm^3 conical flask.
7. Run the organic layer into an evaporating basin and set aside to evaporate to dryness in the fume cupboard to obtain the iodine crystals.

(a) State what you would observe during procedure step **3**. [1]

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(b) Suggest a suitable organic solvent for the extraction of iodine in procedure step **4** and state the change that you would observe. [2]

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(c) State **two** possible systematic errors in this experiment. [2]

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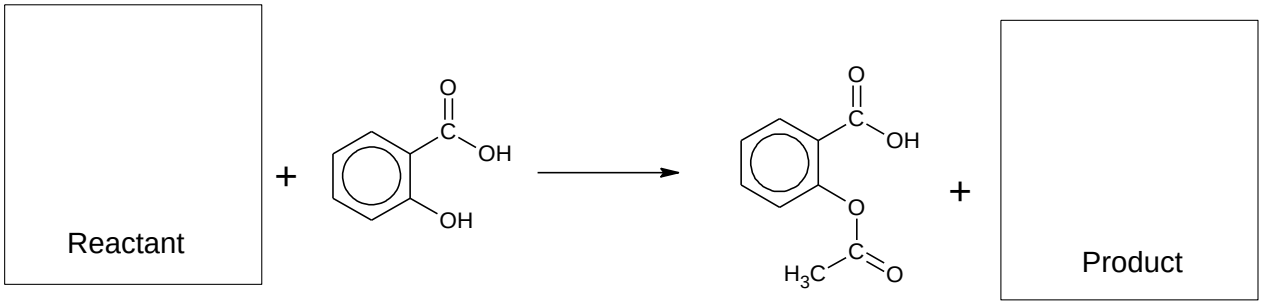
Section B

Option D – Medicinal chemistry

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

3. Aspirin is used as a mild analgesic. The equation below shows the synthesis of aspirin from salicylic acid.



(a) Complete the equation above by drawing the structures of the reactant and product in the boxes below. [2]

Reactant	Product

(b) State the type of reaction for the equation above. [1]

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(Question 3 continued)

(c) Suggest **one** method and explain how it is used to increase the bioavailability of aspirin. [2]

(d) Describe how aspirin works as an analgesic drug. [2]

4. Penicillin is an antibiotic used to treat bacterial infection. The general structure of penicillin is given in section 37 of the data booklet.

(a) Name the part of the structure in penicillin which is responsible for its antibacterial activity and briefly describe the mechanism of the antibacterial activity, including the name of the relevant enzyme involved. [3]

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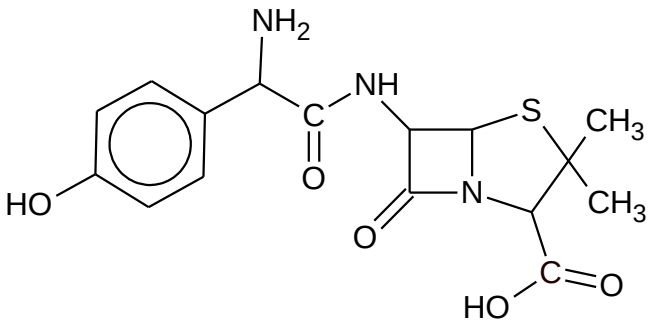
(Question 4 continued)

(b) The structure of a type of penicillin is given below. Identify, by circling, the part of the penicillin structure that can be modified to make it more resistant to the penicillinase enzyme. [1]



(c) Suggest **one** way in which human activities have caused an increase in the resistance to penicillin. [1]

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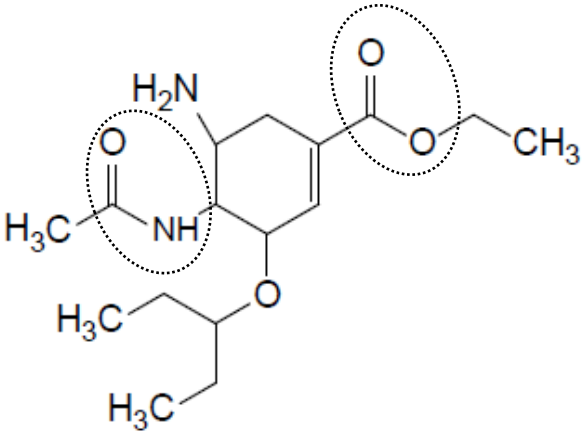
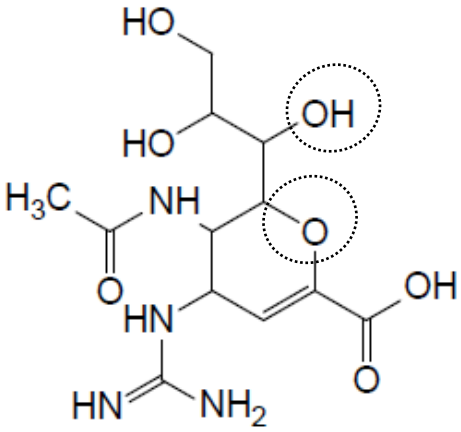
5. Oseltamivir (Tamiflu) and zanamivir (Relenza) are antiviral drugs and their structures are shown below:



Oseltamivir (Tamiflu)



Zanamivir (Relenza)

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(Question 5 continued)

(a) Identify the functional groups that are circled in the structures shown. [2]

Oseltamivir (Tamiflu) : .....

Zanamivir (Relenza) :

(b) Suggest why zanamivir cannot pass through cell membrane as easily as oseltamivir. [2]

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(c) Describe briefly how both antiviral drugs work to treat the influenza virus. [2]

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(d) Oseltamivir drug is commercially synthesized from shikimic acid as a starting material. Discuss a green chemistry approach to obtain shikimic acid and how it reduces the impact on the environment. [2]

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6. Radiotherapy is one of the most common treatments for cancer. Unlike chemotherapy, which usually exposes the whole body to cancer-fighting drugs, radiotherapy is usually a localized treatment.

(a) Technetium-99m is the most widely used medical radioisotope which has a half-life of 6.3 hours. It is usually made on-site in medical facilities from isotopes of molybdenum.

(i) Calculate the radioactive decay constant, λ, for technetium-99m using section 1 of the data booklet and state its unit. [2]

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(ii) Determine the fraction of the technetium-99m sample remaining in the patient after 35.5 hours. [1]

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(iii) Explain why technetium-99m is made on-site. [1]

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(This question continues on the following page)

(Question 6 continued)

(b) Boron Neutron Capture Therapy, BNCT, is a potentially promising treatment for cancer.

(i) Outline how the Boron Neutron Capture Therapy is used to treat cancer. [2]

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(ii) Identify **one** advantage of using Boron Neutron Capture Therapy over Targeted Alpha Therapy and **one** type of cancer commonly treated by BNCT. [2]

Advantage : .....

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Type of cancer : .....

7. The vapor pressure of pure toluene is 400 torr and that of pure 1,2-dimethylbenzene is 150 torr at 90˚C. Assume ideal solution behaviour, determine the composition of toluene in the vapour phase if 0.92 mol of liquid toluene and 0.08 mol of liquid 1,2-dimethylbenzene are mixed at 90˚C. [2]

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End of Paper