Name		Candidate Number	

Anglo-Chinese School
(Independent)

YEAR 6 PRELIMINARY EXAMINATION 2023
INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME
CHEMISTRY HIGHER LEVEL

PAPER 3

Tuesday   **12th September 2023**   **1 hour 15 minutes**

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.
- Write your answers 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.
- All drawings must be in ink.

For examiner's use	
Qn 1	/6
Qn 2	/9
Qn 3	/4
Qn 4	/6
Qn 5	/5
Qn 6	/6
Qn 7	/5
Qn 8	/4
Wrong s.f. /units	
Total	/45

Section A

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

1. Molecules that have a different arrangement as a result of bond rotation are called conformers. Conformers can be represented by the Newman projection. A Newman projection views the carbon-carbon bond directly end-on and represents the two carbon atoms by a circle. Bonds attached to the front carbon are represented by lines to the centre of the circle, and bonds attached to the rear carbon are represented by lines to the edge of the circle. Ethane can have two conformers as a result of the bond rotation: staggered and eclipsed.
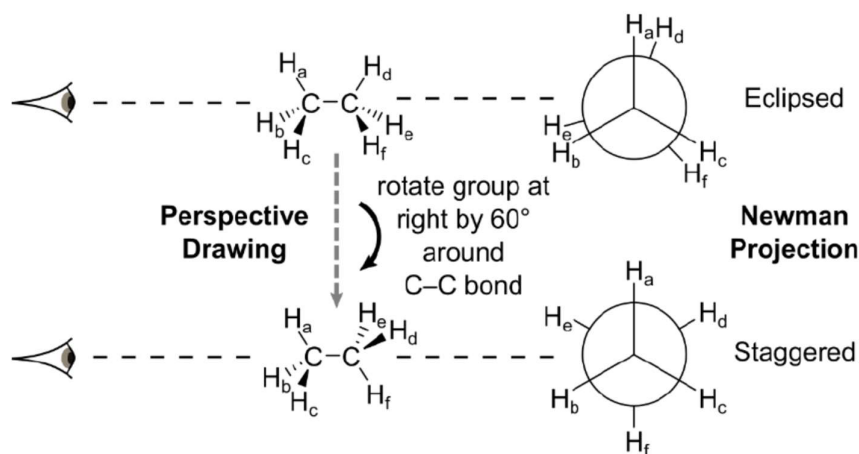
   Using the Newman projection, the angle between the C-H bonds of the front carbon and the C-H bonds on the back carbon is known as the dihedral angle.
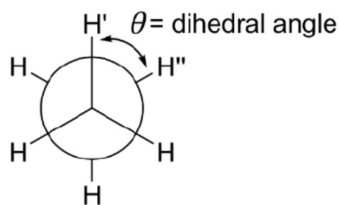
   Butane can have four types of conformers as a result of bond rotation. **Table 1** shows the four conformers of butane. The gauche conformer occurs when the dihedral angle between the methyl groups are 60° apart and the anti conformer occurs when the dihedral angle is 180° apart.

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(Question 1 continued)
Table 1

Conformer	Fully eclipsed	Staggered (Gauche 1)	Eclipsed	Staggered (Anti)
Newman projection				
Dihedral angle between the methyl groups	$0°$	$60°$	$120°$	$180°$

An equilibrium between the gauche 1 and the staggered (anti) conformer can be achieved:
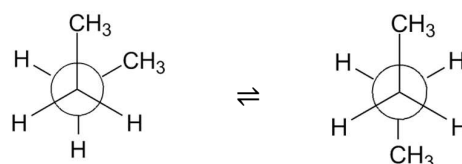
The equilibrium constant, K_c, between the gauche 1 and the staggered (anti) conformer at 298 K can be calculated by the equation given below:

$$- 3630 = -RT \ln K_c$$
$$R = \text{molar gas constant in J mol}^{-1}\text{ K}^{-1}$$
$$T = \text{temperature in Kelvins}$$

(a) Which of the two conformers of butane is the most stable? Explain your answer. [1]

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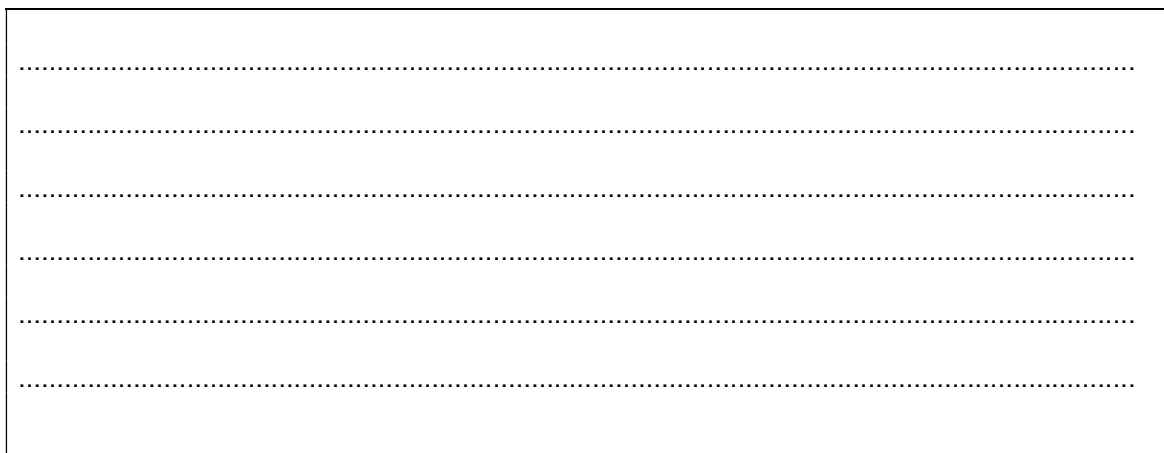
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(Question 1 continued)

(b) (i) There are two gauche conformers of butane. With reference to [1] Gauche 1, draw the other gauche conformer of butane.

(ii) At equilibrium, butane will consist the staggered (anti) conformer [3] and the two gauche conformers. Calculate the equilibrium constant K_c for the equilibrium between the gauche 1 and the staggered (anti) conformer of butane at 298 K. Hence, calculate the percentage of the staggered (anti) conformer of butane at 298 K by using section 2 from the Data Booklet.

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(Question 1 continued)

(c)   A Newman projection for Compound **X** is shown below. State the   [1]
       IUPAC name for Compound **X**.
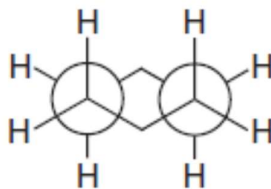
2.   The Finkelstein reaction is a nucleophilic substitution reaction and is carried
      out using dry propanone as a solvent.

      One example of the Finkelstein reaction is given.

$$CH_3CH_2CH_2Br + NaI \rightleftharpoons CH_3CH_2CH_2I + NaBr$$
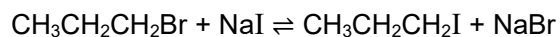
      (a)   (i)   Explain why it is important for propanone to be dry.   [1]

(This question continues on the following page)

(Question 2 continued)

    (a)   (ii)   The solubilities of NaBr and NaI in propanone are shown.

compound	solubility at 25 °C in g / 100g of propanone
NaBr	0.00841
NaI	39.9

                Use this information to explain why the reaction produces a very   [1] high yield despite being a reversible reaction.

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    (b)   State and explain **one** precaution, other than using protective   [1] equipment such as hand gloves, a lab coat or eye protection, that should be taken when carrying out this experiment.

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(Question 2 continued)

(c) A student plans an experiment to show that the rate of the reaction is proportional to the concentration of NaI.

Propanone is used as the solvent in this reaction.

$CH_3CH_2CH_2Br$ (pr) + NaI (pr) $\rightleftharpoons$ $CH_3CH_2CH_2I$ (pr) + NaBr (s)
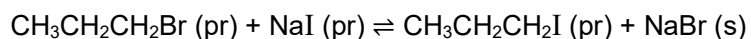
(pr) = substance is dissolved in propanone

The student plans to record the time it takes for the solid formed to obscure a cross on a piece of paper below the conical flask, as shown.
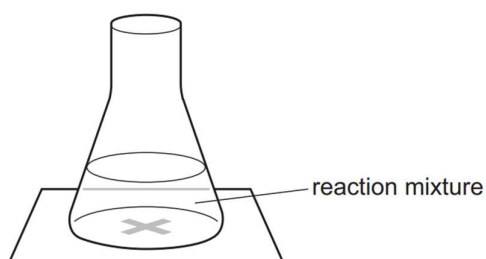
To carry out this experiment, the following materials are available.
- $CH_3CH_2CH_2Br$ (l)
- NaI (s)
- dry propanone, CH_3COCH_3 (l)
- usual laboratory apparatus

(i) The student recorded data in the table below. [2]

Complete the table with appropriate volumes that the student could have used in four further experiments.

volume of 0.5 mol dm^{-3} NaI (pr) / cm^3	volume of $CH_3CH_2CH_2Br$ (l) / cm^3	volume of CH_3COCH_3 (l) / cm^3	total volume / cm^3	time / s
10.0	2.0	30.0	42.0	

(This question continues on the following page)

(Question 2 continued)

(c) (ii) Write an expression to show how the student could calculate the [1]
rate of the reaction.

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(iii) Suggest **one** systematic error and **one** random error associated [2]
with this procedure assuming no human errors occurred and the
stopwatch was accurate.

Systematic error:

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Random error:

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(iv) Suggest an improvement to the experiment to improve the accuracy of [1]
the measurement of rate.

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Section B

Option D – Medicinal chemistry

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

3. Opiates such as morphine and codeine have been used for thousands of years to alleviate pain and are derived from opium.

 (a) Morphine is typically administered parentally to improve its bioavailability. Outline the meaning of the bioavailability of a drug. [1]

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 (b) (i) Diamorphine (heroin) can be synthesised from morphine. Identify the reagent necessary for this reaction using section 37 of the data booklet. [1]

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 (ii) Explain why diamorphine (heroin) is more potent than morphine. [2]

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4. Penicillin was one of the first antibiotics to be isolated and identified for its ability to treat bacterial infections.

(a) Describe how penicillin combats bacterial infections with reference to its structure. Refer to section 37 of the data booklet. [2]

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(b) Some antibiotic-resistant bacteria produce a beta-lactamase enzyme which destroys penicillin activity. Various responses to the challenge of antibiotic resistance have been developed.

(i) Discuss **two** ways in which human activities have caused an increase in resistance to penicillin in bacterial populations. [2]

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(Question 4 continued)

    (b)   (ii)   Suggest how adding clavulanic acid to penicillin enables the [1]
                   antibiotic to retain its activity.
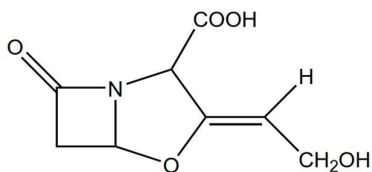
Clavulanic acid

    (c)   A doctor prescribes a broad-spectrum antibiotic for a patient, then some [1]
          days later prescribes a narrow-spectrum antibiotic.

          State the main disadvantage of using a broad-spectrum antibiotic.

5.   (a)   Explain how omeprazole (Prilosec) reduces stomach acidity.   [2]

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(Question 5 continued)

    (b)   The pH inside most cells is maintained at around 7.4 by a phosphate [3] buffer made up of $H_2PO_4^-$ (aq) ion and HPO_4^{2-} (aq). The pK_a of $H_2PO_4^-$ (aq) is 7.2.

        A typical value for the total phosphate concentration in a cell, $[H_2PO_4^-]$ + $[HPO_4^{2-}]$ is 0.020 mol dm^{-3}. Calculate the value of $[HPO_4^{2-}]$ inside a cell.

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6.   (a)   Antiviral medications such as zanamivir (Relenza) are commonly [2] available for commercial use.

        Name **two** functional groups present in zanamivir using section 37 of the data booklet.

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(This question continues on the following page)

(Question 6 continued)

(b)   Discuss **two** difficulties associated with solving the AIDS problem.   [2]

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(c)   Oseltamivir was commercially produced from shikimic acid, a precursor   [2]
which is a metabolite in micro-organisms and plants.

Outline how green chemistry was used to develop the precursor for
oseltamivir in order to overcome the shortage of the drug during the flu
season.

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7. Technetium-99m is the most commonly used isotope for diagnostic medicine.

(a) Discuss the properties that make Technetium-99m suitable for diagnosis. [3]

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(b) Technetium-99m has a half-life of 6.03 hours. Calculate the time taken, in day, for 85% of Technetium-99m to decay [2]

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8. (a) A mixture of 0.250 mol ethyl ethanoate, 0.100 mol ethanol and [2] 0.380 mol ethanoic acid is separated by fractional distillation.

The vapour pressure of pure ethanol at 20 °C is 5.95 kPa.
Calculate the vapour pressure of ethanol above the liquid mixture at 20 °C.

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(b) Taxol is a cancer drug.

(i) State the feature of Taxol that is major challenge of the [1] synthesis, using section 37 of the data booklet.

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(ii) Outline how the challenge in **(b)(i)** was resolved by [1] pharmaceutical companies.

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END OF PAPER