RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATION

CANDIDATE NAME								
CLASS	6							
CENTRE NUMBER	S					INDEX NUMBER				

H2 CHEMISTRY 9647/02

Paper 2 Structured Questions **13 September 2011**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
A Data Booklet is provided. Do not write anything on it.

The number of marks is given in brackets [ ] at the end of each question or part question.
At the end of the examination, fasten all your work securely together.

For Examiner's Use	
1	
2	
3	
4	
5	
Total	

Answer **all** questions in the space provided.

1. Planning (P)

John went on an excursion to a limestone cave in Gunung Mulu National Park, Sarawak. In there, he picked up a limestone rock and decided to investigate the percentage by mass of $CaCO_3$ in this rock sample. When he was back in his school laboratory, he weighed the rock sample and the reading was 0.200 g.

(a) $2H^+ + CO_3^{2-} \longrightarrow CO_2 + H_2O$

Given the equation above, draw a labelled experimental setup of how collection of CO_2 gas can be achieved. **[3]**

(b) Given that the percentage by mass of $CaCO_3$ in the limestone rock sample is at least 60% and assuming that other substances in the rock sample are inert to acid, calculate the volume of 0.100 mol dm^{-3} of HC*l* that should be used to react with the rock sample.

A_r: Ca, 40.1; C, 12.0; O, 16.0;
Assuming that the experiment is carried out under room temperature and pressure, 1 mole of gas occupies 24000 cm^3 under these conditions.

[2]

(c) Using the information given in **(a)** and **(b)**, calculate the volume of the apparatus needed for the collection of CO_2 gas in this experiment. **[2]**

(d) With the help of your diagram in **(a)**, describe the procedure to find the percentage mass of $CaCO_3$ in the rock sample.

Your plan should give a step-by-step description of the method, including the calculations to determine the percentage by mass of $CaCO_3$. **[3]**

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(e) Suggest a possible error in the above experiment and propose how it can be minimised. **[2]**

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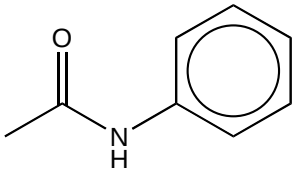
[Total: 12]

2. N-Phenylethanamide, a drug once used to reduce fever, has the following structure:



N-Phenylethanamide

N-Phenylethanamide may be synthesised by reacting phenylamine with an acid chloride prepared by the reaction of ethanoic acid with thionyl chloride. The procedure of the synthesis is as described below.

Some data about the compounds involved in the synthesis are given in the table below.

Compound	**Formula**	**Density / g cm^{-3}**	M_r
Glacial ethanoic acid	CH_3COOH	1.05	60
Thionyl chloride	$SOCl_2$	0.94	119.1
Phenylamine	$C_6H_5NH_2$	1.02	93
N-Phenylethanamide	Given above	1.22	135

Preparation of impure N-phenylethanamide

1 Place 6 cm^3 of glacial ethanoic acid in a clean and dry 250 cm^3 round bottom flask. Place a dropping funnel in the neck of the flask.

2 Place 20 cm^3 of thionyl chloride in the dropping funnel and add the thionyl chloride gradually over the course of 10 minutes. Ensure that the reaction mixture is stirred well.

3 When all the thionyl chloride has been added, gently heat the reaction mixture for 20 minutes.

4 Cool the mixture to room temperature and replace the dropping funnel with a new one. Place 20 cm^3 of phenylamine in the new dropping funnel and add the amine gradually over the course of 10 minutes. Ensure that the reaction mixture is stirred well.

5 When all the phenylamine has been added, allow the mixture to stir for about 20 minutes.

(a) The synthesis of N-phenylethanamide is a two-stage process, the first being the formation of an acid chloride and the second being the reaction between the acid chloride and phenylamine.

Using structural formulae, write an equation for **each** of these stages. **[2]**

Stage 1:

Stage 2:

(b) Glacial ethanoic acid (step 1) refers to a liquid sample of water-free ethanoic acid. Suggest why it is used over an aqueous solution of ethanoic acid. **[1]**

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The reaction mixture after step 5 contains N-phenylethanamide and excess phenylamine. Pure N-phenylethanamide can be obtained from the mixture through the sequence of steps described below.

Data about the compounds involved in the purification process are given in the table below.

Compound	Density / g cm^{-3}	Solubility in water
Phenylamine	1.02	moderate
N-phenylethanamide	1.22	insoluble
Diethyl ether	0.71	partial
Water	1.00	–

Purification of impure N-phenylethanamide

6 Pour the reaction mixture into a separating funnel and add about a third its volume of diethyl ether.

7 Add 15 cm^3 of 5% HC*l* and 15 cm^3 of saturated sodium chloride solution into the separating funnel. Shake the mixture and allow the two layers to separate. Discard the aqueous layer.

8 Repeat Step 7 for 2 to 3 times, discarding the aqueous layer each time.

9 Pour 15 cm^3 of 10% sodium hydrogen carbonate into the separating funnel and shake the mixture cautiously. Allow the two layers to separate then discard the aqueous layer.

10 Transfer the organic layer into a round bottom flask. Evaporate the diethyl ether off using a Rotary Film Evaporator to obtain pure N-phenylethanamide.

(c) After diethyl ether was added to the impure N-phenylethanamide (step 6), the mixture is shaken with 5 % HC*l* and saturated sodium chloride solution and the two layers are allowed to separate (step 7).

(i) Suggest why ethanol is not a good organic solvent for this separation technique.

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(ii) Suggest why saturated sodium chloride solution was added (step 7).

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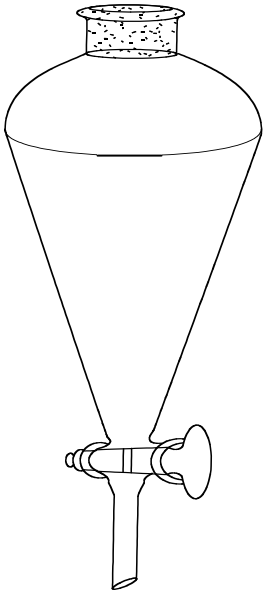
(iii) In the diagram of the separating funnel below, draw the two layers that will be observed after step 7. Indicate the **relative position** of the two layers and state the **organic** species present in each layer. **[4]**



(d) The organic layer is washed with 10% sodium hydrogen carbonate (step 9) before the ether solvent was evaporated off.

(i) Write an equation to show how the impurity is removed in this step.

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(ii) Besides shaking the separating funnel cautiously, suggest another safety procedure for this step. **[2]**

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(e) The ether solvent is evaporated off using a Rotary Film Evaporator (step 10) to obtain the pure N-phenylethanamide as a white solid.

(i) It is very difficult to remove water using a Rotary Film Evaporator, hence, a granular drying agent is usually added to the organic layer after separation. The mixture is swirled until the liquid is clear and the mixture is filtered before the ether is evaporated.

Suggest a drying agent that can be used.

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(ii) 8.94 g of N-phenylethanamide was obtained after all the ether solvent was removed. Calculate the percentage yield for this reaction.

(iii) Suggest a method to further purify the N-phenylethanamide obtained after step 10. **[5]**

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[Total: 14]

3. Magnesium and aluminium are Period 3 elements with wide uses in industry.

(a) Magnesium nitrate, magnesium chloride and aluminium chloride can be made by direct reaction of the respective metal with the corresponding acid. However aluminium nitrate cannot be easily obtained by direct reaction of aluminium metal with nitric acid due to a phenomenon known as passivation in which an impervious layer of aluminium oxide forms on the surface of the aluminium metal. As such aluminium nitrate is formed by reacting aluminium chloride with nitric acid.

Use of *Data Booklet* may be helpful in this question

(i) Suggest the role of nitric acid in the reaction of aluminium and nitric acid.

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(ii) Using a chemical equation, suggest a possible equation the reaction that may occur at the surface of the aluminium.

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(iii) Aluminum metal and aluminium oxide both undergo separate reactions with aqueous sodium hydroxide to give the same aluminium containing compound. Write an equation for the reaction of aluminium metal and aqueous sodium hydroxide given that a colourless gas which extinguishes a lighted splint with a 'pop' sound is also produced. **[3]**

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(b) Aluminium oxide has a melting point of 2072 °C while aluminium chloride sublimes at 180 °C. Explain this in terms of structure and bonding. **[2]**

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(c) Group II nitrates such as magnesium nitrate and barium nitrate decompose on heating.

(i) Write an equation including state symbols for the decomposition of magnesium nitrate on heating.

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(ii) Magnesium nitrate has a decomposition temperature of 330 °C while barium nitrate has a decomposition temperature of 592 °C.

Explain the difference in the decomposition temperatures.

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(iii) How would you expect the decomposition temperature of aluminium nitrate to compare with that of magnesium nitrate?

Explain your answer using data from the *Data Booklet*. **[5]**

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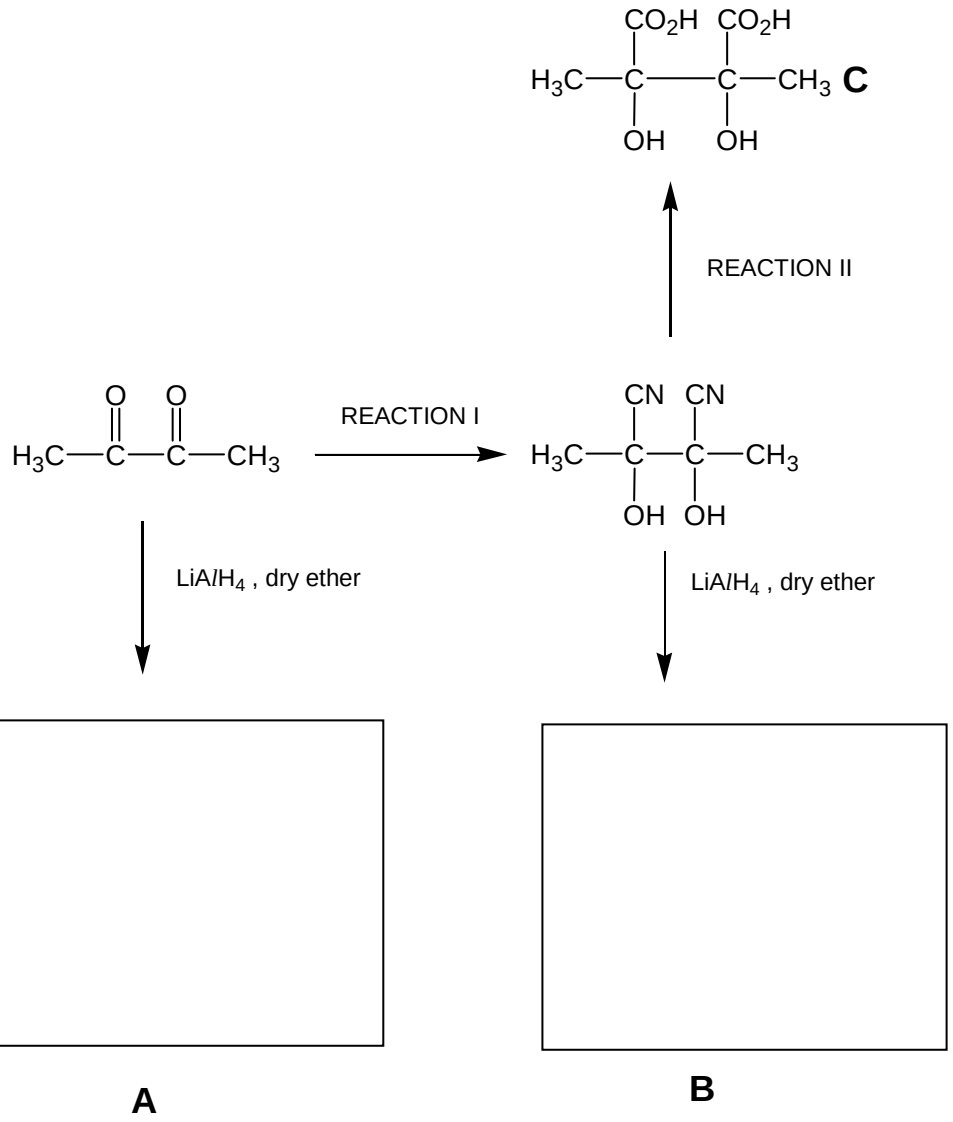
(c) Aluminium containing compounds such as lithium aluminium hydroxide and aluminium oxide are useful in organic synthesis. Consider the following series of reactions.



(i) State the reagents and conditions for :

Reaction I: ……..

Reaction II: ……..

(ii) Draw the structures of compound **A** and **B** in the space provided. **[4]**

[Total: 14]

4. Over one million tonnes of chromium are produced in the world each year and about 30 % of it is used in electroplating. In an electroplating experiment, an aqueous solution containing chromium(III) sulfate was electrolysed using a piece of pure chromium and the metal object to be electroplated as the electrodes.

(a) A current was passed for 1.5 hours and the mass of the metal object was found to increase by 3.7 g. Calculate the current used. **[2]**

(b) The experiment was repeated using aqueous aluminium sulfate instead of chromium(III) sulfate, and a piece of pure aluminium instead of chromium.

Explain why aluminium will not be electroplated on the metal object. Hence, write the equations, including state symbols, for the reactions which occur at the anode and cathode. **[3]**

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(c) Give the electronic configuration of chromium(III) ion. Hence, explain why aqueous chromium(III) sulfate is coloured. **[3]**

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(d) In a separate experiment, a chemist prepared two complexes with the general formula $CrCl_3.6H_2O$. Upon adding $AgNO_3(aq)$ to aqueous solutions of **P** and **Q**, he noted the following:

Solution	Amount of AgCl precipitated per mole of solution
P	1
Q	2

Based on these observations, deduce the formula of **P** and **Q** in the solutions. Explain your answer, providing relevant equations. **[4]**

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(e) Draw an appropriate energy level diagram to determine the lattice energy of chromium(III) nitrate, $Cr(NO_3)_3$.

The following enthalpy changes are given:

Enthalpy change of hydration of chromium ion	= –4563 kJ mol^{-1}
Enthalpy change of hydration of nitrate ion	= –314 kJ mol^{-1}
Enthalpy change of solution of chromium(III) nitrate	= –35 kJ mol^{-1}

[3]

Energy ↑

[3]

[Total: 15]

5. Alkenes are useful starting materials for the synthesis of many intermediates used to make polymers and other industrial chemicals.

(a) The "OXO" reaction is industrially important for making alcohols, aldehydes and carboxylic acids from alkenes. For example, propene can be converted into butanal as follows:

$$CH_3CH{=}CH_2(g) + CO(g) + H_2(g) = CH_3CH_2CH_2CHO(g)$$

(i) Write an expression for K_p for the "OXO" reaction.

(ii) When equimolar mixture of propene, CO and hydrogen gas at an initial total pressure of 120 atm is allowed to reach equilibrium at 500 K, the partial pressure of butanal is found to be 39.6 atm.

Calculate the value of K_p at 500 K and state the units.

(iii) Suggest why this reaction is carried out at 120 atm. **[5]**

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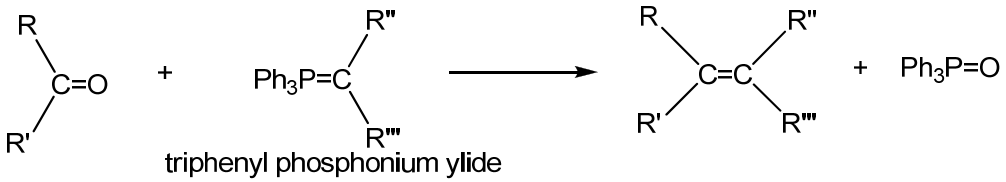
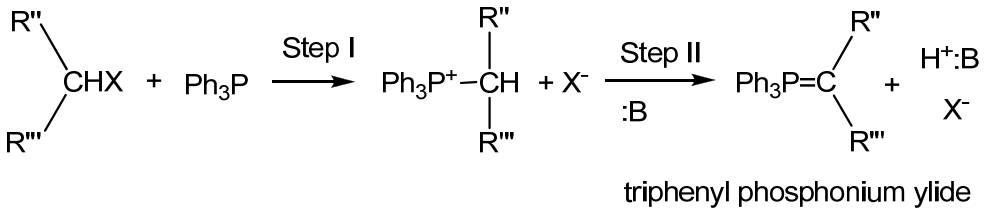
(b) For alkenes to be useful starting materials for synthesis of organic chemicals, it is important to synthesise alkenes with the carbon-carbon double bonds at specific positions with no ambiguity.

In 1954, a German chemist Georg Wittig reported a method of synthesising alkenes from ketones and aldehydes using a reagent known as triphenyl phosphonium ylide, $Ph_3P=CRR'$, which is also known as Wittig reagent.



Wittig reagents can be produced by the reaction of alkyl halides with triphenylphosphine in the following two-step processes.



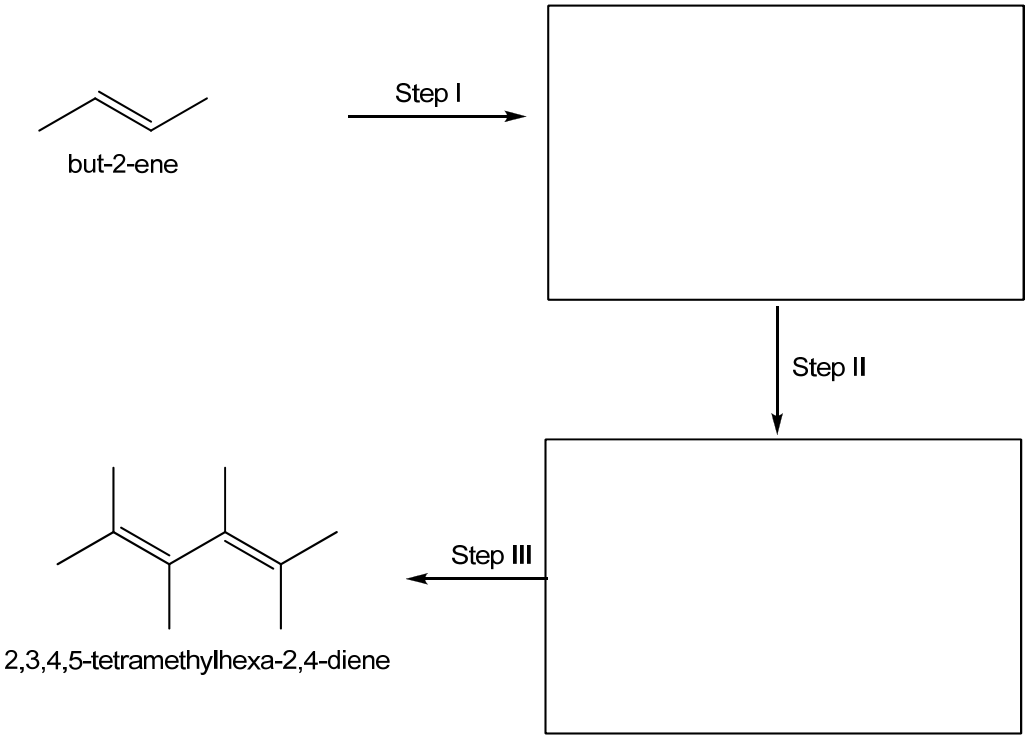
(i) Name the reaction that takes place in Step I to form triphenyl phosphonium ylide.

Step I : ……..

(ii) Draw the structural formula of the final organic product when the ylide, $Ph_3P=CHCH_3$ is reacted with propanone, CH_3COCH_3 in the Wittig reaction.

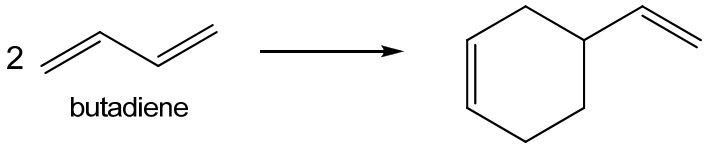
(iii) The conversion of but-2-ene to 2,3,4,5-tetramethylhexa-2,4-diene involves 3 steps. Step II is an oxidation reaction and a Wittig reagent is used in one of the steps.

Draw the structures of the intermediates and the Wittig reagent in the space provided. **[5]**



Structure of Wittig reagent:

(c) Alkenes with multiple carbon-carbon double bonds held together by carbon-carbon single bond are known as conjugated alkenes. The simplest conjugated alkene is butadiene. Conjugation enables the double bonds to exhibit some chemical properties that are not found in alkenes with isolated double bonds. For example, butadiene undergoes dimerisation to form 4-vinylcyclohex-1-ene.



To determine the rate equation, an experiment was carried out to collect experiment data on the partial pressure of butadiene ($p_{butadiene}$) measured at a constant temperature of 500 K. The results were given in Table 1 below.

Table 1

Time /s	$p_{butadiene}$ /atm	Rate /atm s^{-1}		
0	0.917	9.48×10^{-5}		
1000	0.827	7.75×10^{-5}		
2000	0.753	6.45×10^{-5}		
3000	0.691	5.45×10^{-5}		
4000	0.638	4.67×10^{-5}		

(i) State the general rate equation for dimerisation of butadiene.

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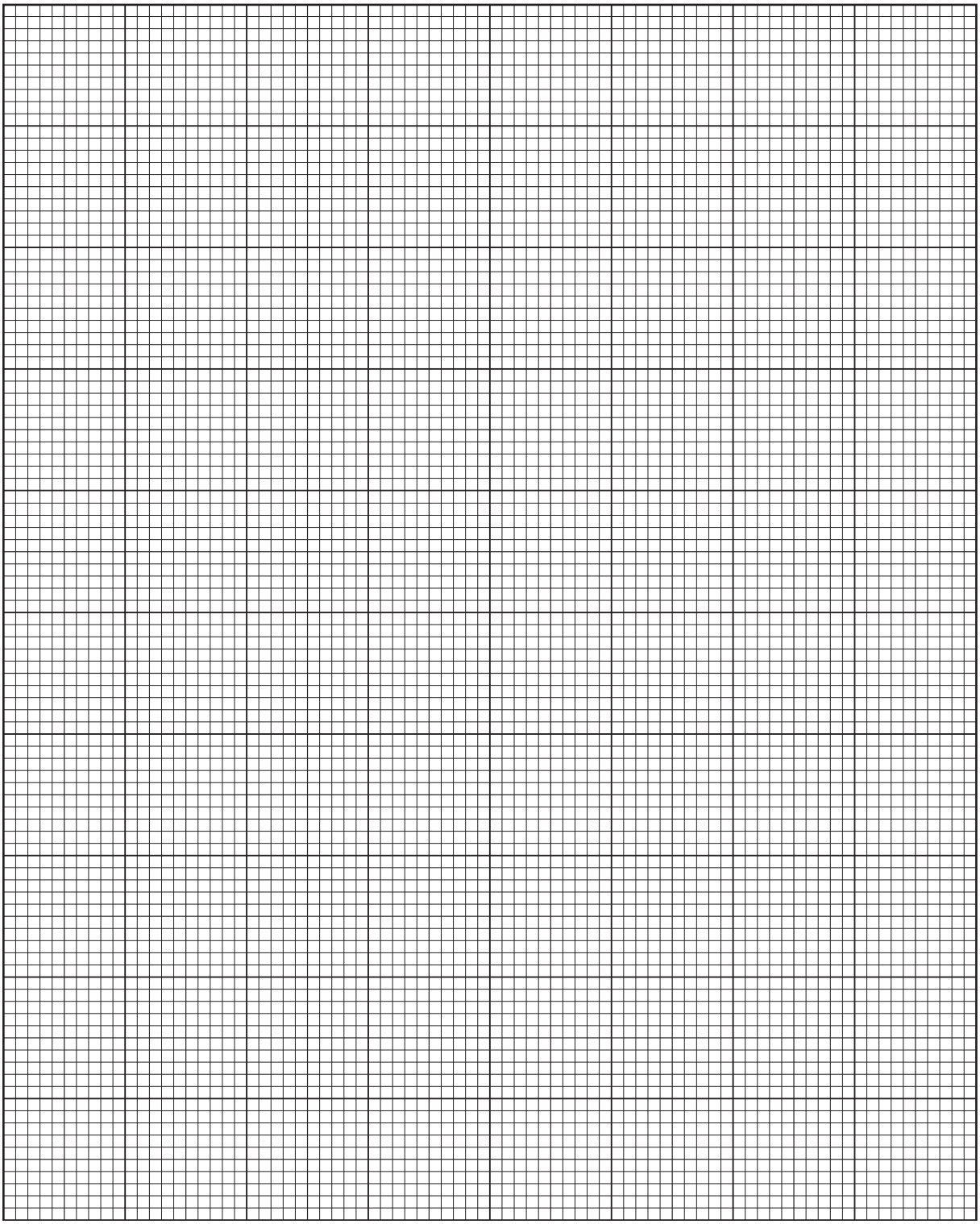
(ii) Process the results in the Table 1 to produce data that would enable you to deduce the order of reaction with respect to butadiene. Record these data in the additional columns of the table. You must use at least one of the additional columns.

(iii) Present the data calculated in **(ii)** in a graphical form. Draw the line of best-fit, showing clearly the y-intercept. Hence deduce the order of reaction with respect to butadiene.



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(iv) A student repeated the experiment at the temperature of 300K. Sketch, on the same axes in **(iii)**, the graph obtained by this student. Label this graph as **300 K**. **[7]**

[Total: 17]