Paper Reference(s) **9CH0/02**

Pearson Edexcel Level 3 GCE

Chemistry
Advanced
Paper 2: Advanced Organic and Physical Chemistry

Monday 19 June 2017 – Morning

Time: 1 hour 45 minutes plus your additional time allowance

INSTRUCTIONS TO CANDIDATES
Write your centre number, candidate number, surname, other names and your signature in the boxes below. Check that you have the correct question paper.

Centre No.						
Candidate No.						
Surname						
Other names						
Signature						
Paper Reference	9	C	H	0	/	0	2

- Use BLACK ink or BLACK ball-point pen.
- Answer ALL questions.
- Answer the questions in the spaces provided – there may be more space than you need.

MATERIALS REQUIRED FOR EXAMINATION

Data Booklet, scientific calculator, ruler

ITEMS INCLUDED WITH QUESTION PAPERS

Periodic table, separate sheet for use with question 9(d)

INFORMATION FOR CANDIDATES

- The total mark for this paper is 90.
- The marks for EACH question are shown in brackets – use this as a guide as to how much time to spend on each question.
- For the question marked with an ASTERISK (*), marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is provided.

ADVICE TO CANDIDATES

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- Show all your working in calculations and include units where appropriate.

(Turn over)

Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒.

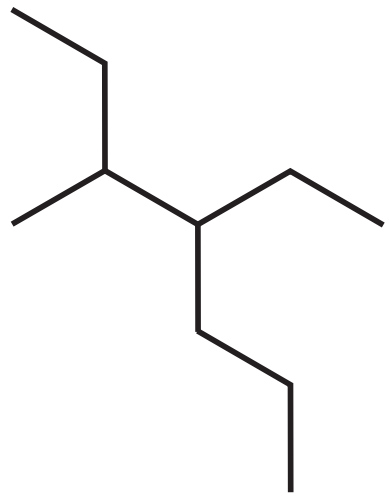
1 This is a question about alkanes.

(a) What is the reaction mechanism when ethane and chlorine react in UV light? (1 mark)

- ☐ **A electrophilic addition**
- ☐ **B electrophilic substitution**
- ☐ **C free radical addition**
- ☐ **D free radical substitution**

(Question continues on next page)

(b) What is the name of this alkane? (1 mark)



- ☐ A 2-ethyl-3-propylpentane
- ☐ B 4-ethyl-3-methylheptane
- ☐ C 3-methyl-4-propylhexane
- ☐ D 4-methyl-3-propylhexane

(Question continues on next page)

(c) Alkanes are obtained by processing crude oil.

(i) Explain why different alkanes in crude oil can be separated by fractional distillation. (2 marks)

(Question continues on next page)

(ii) Complete the equation for the cracking of octane to produce ethene and only one other organic compound. State symbols are not required. (1 mark)

$C_8H_{18} \longrightarrow$ _____ + _____

(iii) Write the equation for the reforming of hexane into cyclohexane, using DISPLAYED formulae for the organic compounds. State symbols are not required. (1 mark)

(TOTAL FOR QUESTION 1 = 6 MARKS)

(Questions continue on next page)

2 Diamond, graphene and graphite are different forms of carbon.

(a) The structural feature that graphene and graphite have in common is that the carbon atoms are arranged in (1 mark)

☐ A layers with each atom bonded to four others

☐ B hexagonal and pentagonal rings within a layer

☐ C hexagonal rings within a layer

☐ D a three-dimensional structure

(b) The bond angles within a layer of graphene and a layer of graphite are (1 mark)

☐ A 90^{o} and $109{\cdot}5^{o}$

☐ B all $109{\cdot}5^{o}$

☐ C $109{\cdot}5^{o}$ and 120^{o}

☐ D all 120^{o}

(Question continues on next page)

(c) One way in which diamond differs from graphene and graphite is that only diamond has (1 mark)

☐ A a high melting temperature

☐ B a precise molecular formula

☐ C poor electrical conductivity

☐ D a giant structure

(TOTAL FOR QUESTION 2 = 3 MARKS)

(Questions continue on next page)

3 This is a question about halogenoalkanes and related compounds.

(a) Explain the trend in reactivity of the PRIMARY chloro-, bromo- and iodoalkanes with aqueous hydroxide ions. (2 marks)

(Question continues on next page)

(b) In aqueous sodium hydroxide, 1-bromoethane reacts to produce ethanol.

(i) Write the mechanism for this reaction, including all relevant curly arrows, lone pairs and dipoles. Include the transition state.
(4 marks)

(Question continues on next page)

(ii) Give the reagents that are used to test that bromide ions are formed in this reaction mixture. Include the result of the test.
(2 marks)

(Question continues on next page)

(c) The halogenoalkane 2-bromobutane reacts with ethanolic potassium hydroxide to produce a mixture of alkenes.

Draw the SKELETAL formulae of all the alkenes that could be produced. (3 marks)

(Question continues on next page)

(d) Explain why ethene has a boiling temperature of –104 °C, whereas ethanol has a boiling temperature of 78 °C. (3 marks)

(TOTAL FOR QUESTION 3 = 14 MARKS)

(Questions continue on next page)

4 Traditionally, high-flying aircraft and Formula 1 racing cars have had their tyres inflated with nitrogen gas instead of air. Recently, this practice has been extended to some other cars.

(a) A car tyre is filled with nitrogen gas to a volume of 8·98 dm^3 and a pressure of 207 kPa at 20 ^oC.

(i) Using the Ideal Gas Equation, calculate the mass of nitrogen gas, in grams, present in the car tyre under these conditions. Give your answer to an appropriate number of significant figures. (3 marks)

(Question continues on next page)

(ii) During a car journey, the tyres become warm. Use the Ideal Gas Equation to deduce the effect that this has on the pressure in the tyres. (1 mark)

(Question continues on next page)

(b) One reason for the use of nitrogen gas in car tyres is that less gas is lost from the tyres during use because nitrogen molecules are larger than oxygen molecules. A suggested explanation for this is that nitrogen atoms are larger than oxygen atoms.

Explain why a nitrogen atom is larger than an oxygen atom. (2 marks)

(TOTAL FOR QUESTION 4 = 6 MARKS)

(Questions continue on next page)

5 This is a question about catalytic converters in car exhaust systems.

(a) When petrol is burnt in a car engine, pollutant gases including carbon monoxide and nitrogen monoxide are formed.

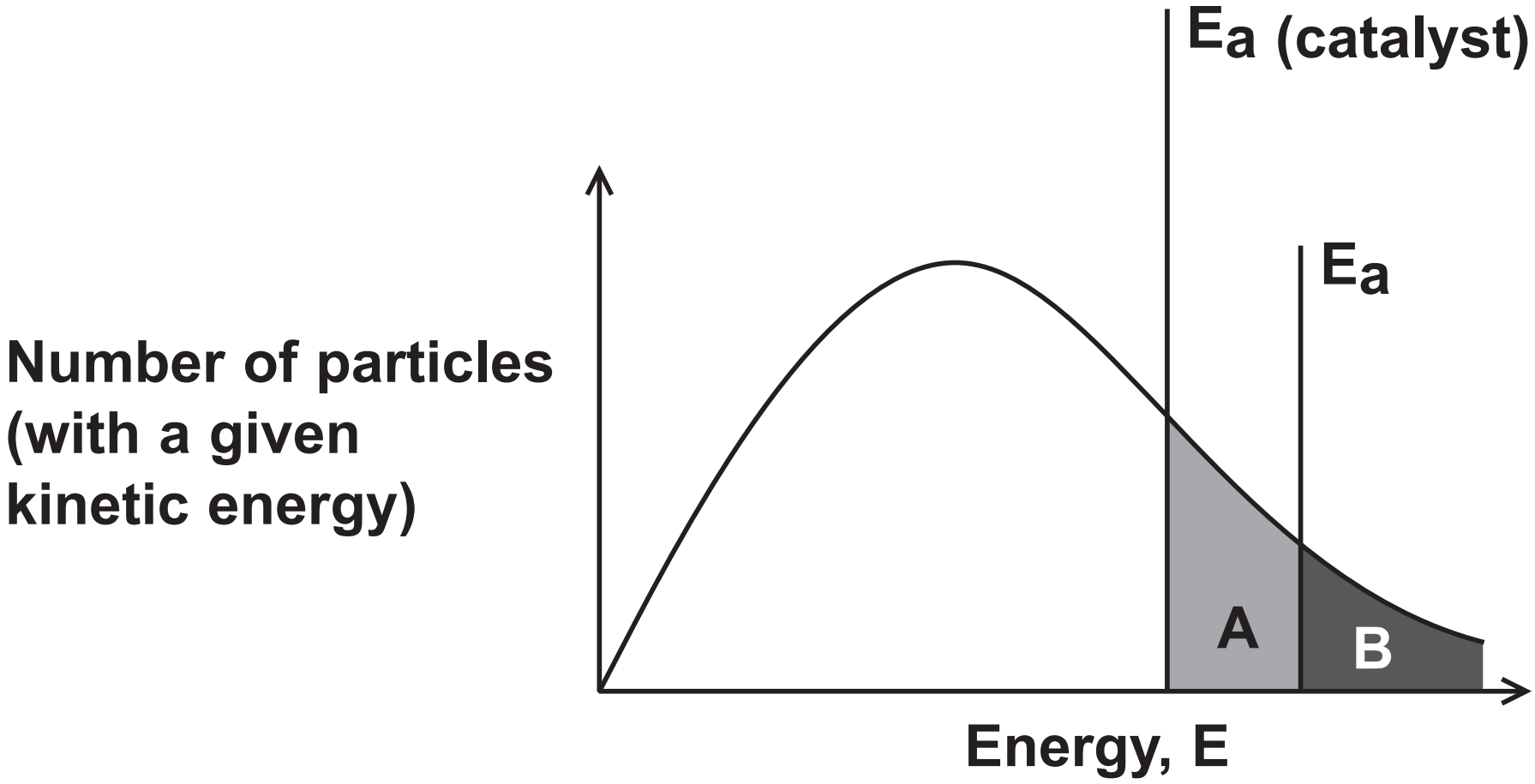
(i) Write the equation for the reaction between these two polluting gases that takes place on the surface of a catalytic converter. State symbols are not required. (1 mark)

(Question continues on next page)

(ii) Describe the stages by which the reaction in (a)(i) occurs in a catalytic converter. (3 marks)

(Question continues on next page)

(b) Which area in the Maxwell-Boltzmann distribution diagram represents the INCREASE in the number of particles with sufficient energy to react in the presence of a catalyst? (1 mark)



☐ A area A

☐ B area B

☐ C area A – area B

☐ D area A + area B

(Question continues on next page)

(c) In the UK, the exhaust emissions of a petrol-fuelled vehicle must be less than 1·00 g of carbon monoxide per kilometre.

What is the maximum number of carbon monoxide molecules that can be emitted per kilometre for a vehicle to meet this regulation? (1 mark)

☐ A $1{\cdot}37 \times 10^{22}$

☐ B $2{\cdot}15 \times 10^{22}$

☐ C $6{\cdot}02 \times 10^{23}$

☐ D $1{\cdot}69 \times 10^{25}$

(TOTAL FOR QUESTION 5 = 6 MARKS)

(Questions continue on next page)

6 This is a question about polymerisation.

(a) But-1-ene and cyclohexene both form addition polymers.

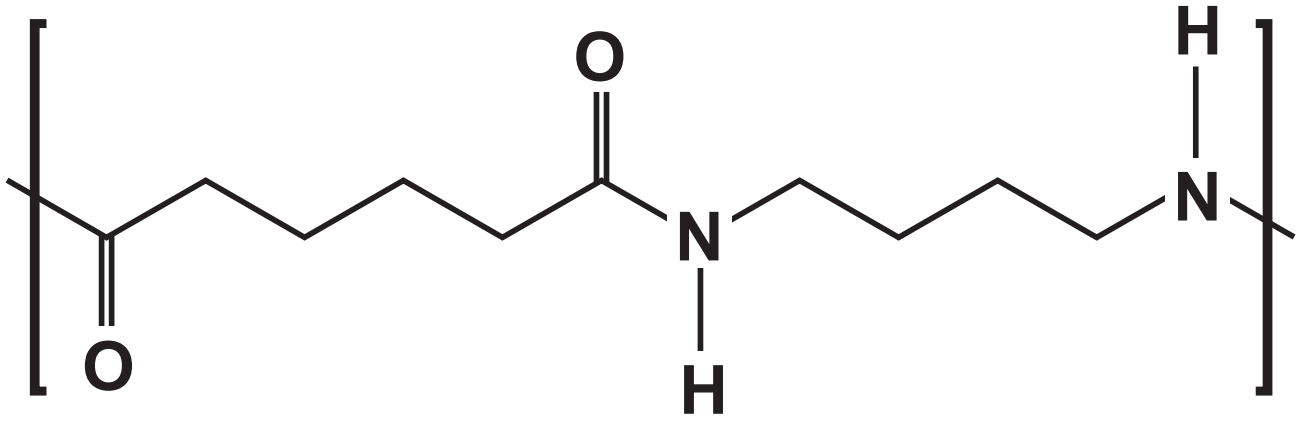
Draw a section of each polymer, showing TWO repeat units. (2 marks)

$CH_2{=}CHCH_2CH_3$ →

→

(Question continues on next page)

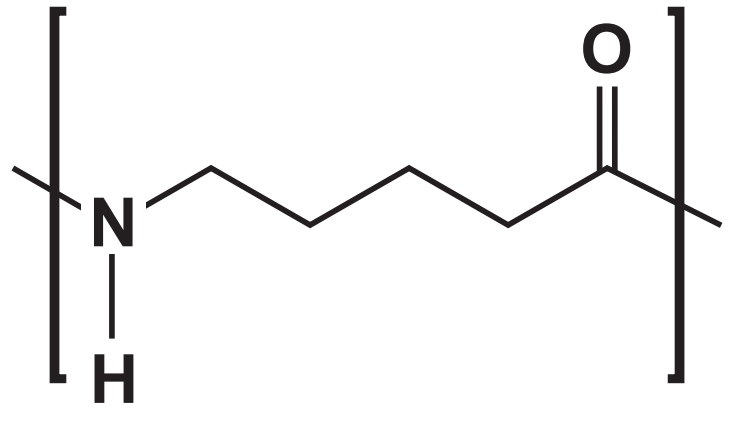
(b) Deduce the two monomers needed to produce the polyamide shown. (2 marks)



and

(Question continues on next page)

(c) Deduce the single monomer that could be used to produce the polyamide shown. (1 mark)



(Question continues on next page)

(d) PLA is a biodegradable polyester which is made from 2-hydroxypropanoic acid, $CH_3CH(OH)COOH$.

(i) Draw the two enantiomers of 2-hydroxypropanoic acid. (2 marks)

(ii) State how separate samples of these two enantiomers could be distinguished in a laboratory. (1 mark)

(Question continues on next page)

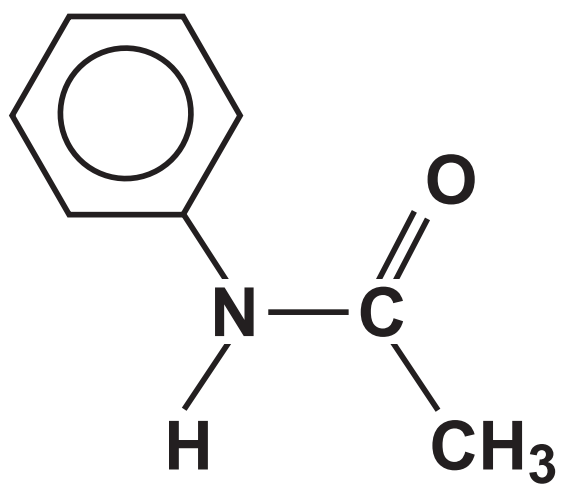
(iii) Biodegradable polyesters break down naturally.

State why this is an advantage. (1 mark)

(TOTAL FOR QUESTION 6 = 9 MARKS)

(Questions continue on next page)

7 **Antifebrin was the trade name for N-phenylethanamide which was used as a painkiller until paracetamol was discovered.**



Antifebrin

(a) Some of the following reagents can be used to produce Antifebrin from benzene.

- **Aluminium chloride**
- **Ammonia, concentrated**
- **Benzene**
- **Ethanal**
- **Ethanoic acid**
- **Ethanol**
- **Ethanoyl chloride**
- **Hydrochloric acid, concentrated**
- **Hydrochloric acid, dilute**
- **Iron**
- **Nitric acid, concentrated**
- **Nitric acid, dilute**
- **Propanone**
- **Sodium chloride**
- **Sulfuric acid, concentrated**
- **Tin**

Selecting from only these reagents, devise a THREE-STEP synthetic pathway to convert benzene into Antifebrin. You should include the structures of the two intermediate compounds and the reaction conditions. (5 marks)

(Answer on next page)

(Question continues on next page)

(b) What is the number of peaks in a C-13 NMR spectrum of Antifebrin? (1 mark)

☐ A 5

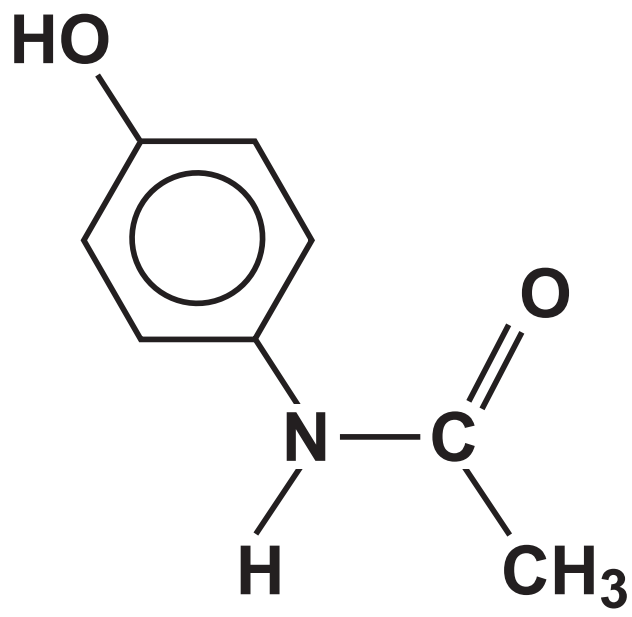
☐ B 6

☐ C 7

☐ D 8

(Question continues on next page)

(c) **Paracetamol is structurally similar to Antifebrin, but has a hydroxy group attached directly to the benzene ring.**



The bromination of the benzene ring in paracetamol occurs much more readily compared to the bromination of benzene.

Explain this increased reactivity. (2 marks)

(Question continues on next page)

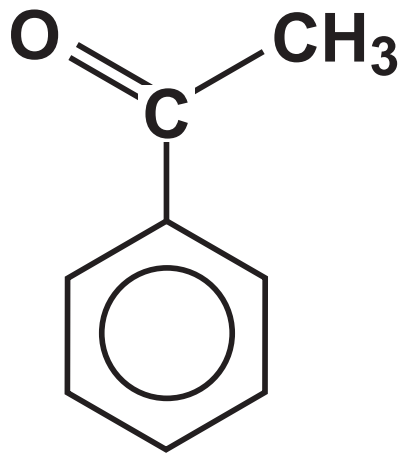
(d) A tablet with a total mass of 500 mg contained $3{\cdot}10 \times 10^{-3}$ mol of paracetamol.

Calculate the percentage by mass of paracetamol in the tablet, quoting your answer to an appropriate number of significant figures.
(2 marks)

(TOTAL FOR QUESTION 7 = 10 MARKS)

(Questions continue on next page)

8 **Phenylethanone is an ingredient in many types of chewing gum.**

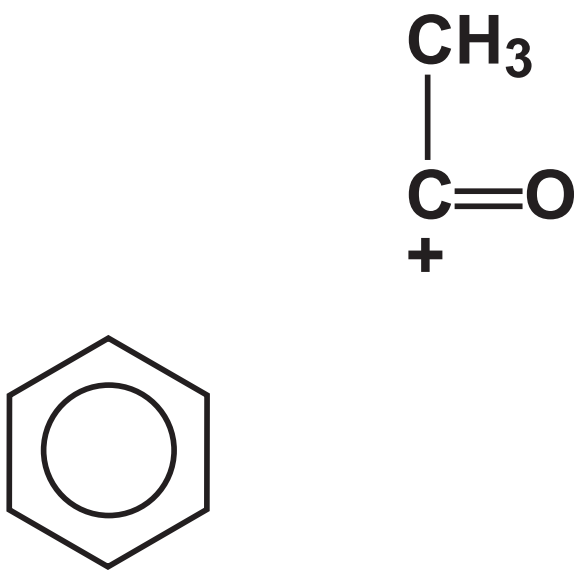


One method for the production of phenylethanone involves the reaction of benzene with ethanoyl chloride, CH_3COCl.

(a) (i) Write the equation for the formation of the electrophile, CH_3CO^+, from ethanoyl chloride using the catalyst aluminium chloride.
(1 mark)

(Question continues on next page)

(ii) Complete the diagram, including curly arrows, to show the mechanism for the reaction between this electrophile and benzene to produce phenylethanone. Include the regeneration of the catalyst. (4 marks)



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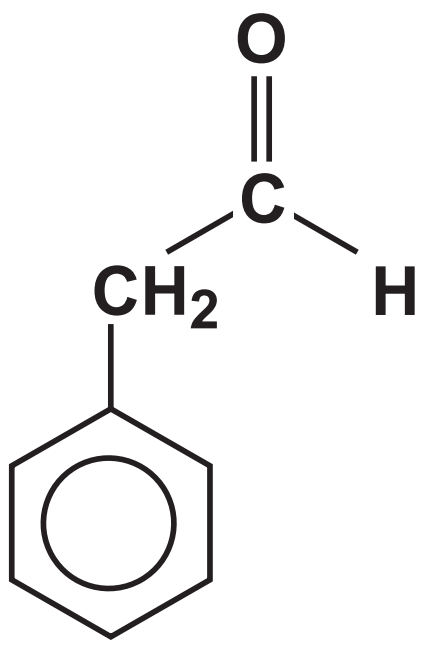
(b) Phenylethanone can be distinguished from its structural isomer, phenylethanal, in a number of different ways.



(i) Which would react with phenylethanone but NOT with phenylethanal? (1 mark)

☐ A acidified sodium dichromate(VI)

☐ B alkaline iodine solution

☐ C Fehling's solution

☐ D Tollens' reagent

(Question continues on next page)

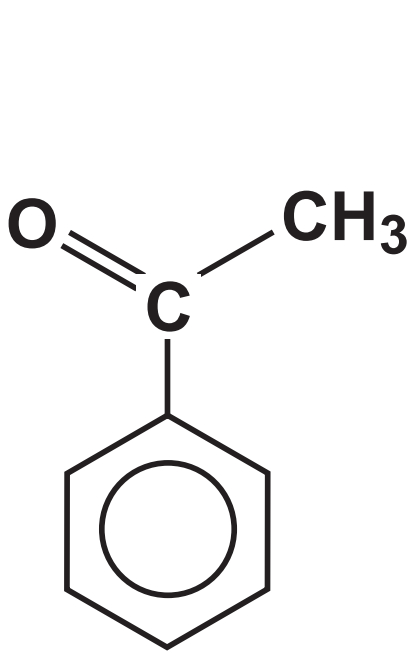
(ii) Give the steps to show how 2,4-dinitrophenylhydrazine could be used to distinguish between phenylethanone and phenylethanal. (4 marks)

(Continue your answer on next page)

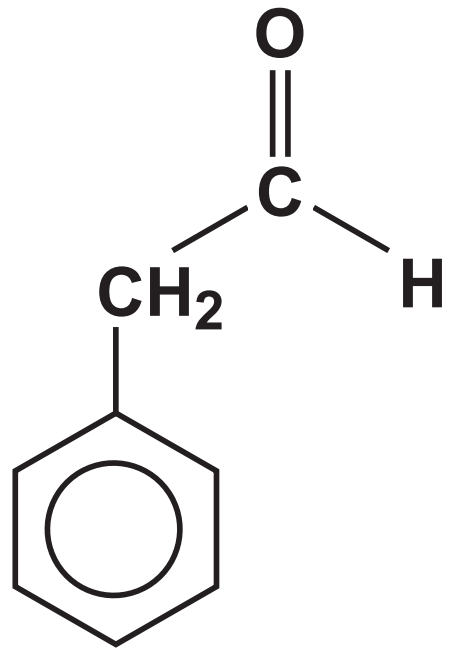
(Question continues on next page)

*(iii) Compare and contrast the high resolution proton NMR spectra of phenylethanone and phenylethanal.

You should use the Data Booklet. (6 marks)



Phenylethanone



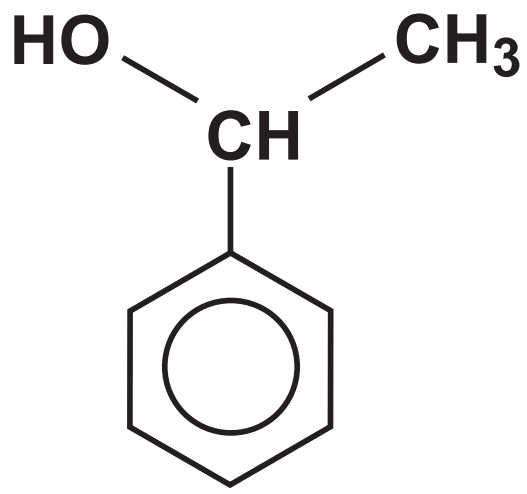
Phenylethanal

(Continue your answer on next page)

(Continue your answer on next page)

(Question continues on next page)

(c) **The compound 1-phenylethanol can be formed from phenylethanone.**



Give the reagent and conditions that would be used to form 1-phenylethanol. (2 marks)

(TOTAL FOR QUESTION 8 = 18 MARKS)

(Questions continue on next page)

9 This question is about reaction kinetics.

(a) Compound A decomposes in a first order reaction.

Calculate the time it takes for the mass of A to decrease from 600 g to 37·5 g if the decomposition has a constant half-life of 14 minutes. (1 mark)

(b) The 'initial rates' method was used to investigate the orders of reaction with respect to reactants X, Y and Z. The table shows the results obtained.

Run	Initial concentration / mol dm^{-3}			Initial rate / mol dm^{-3} s^{-1}
	X	Y	Z	
1	0·00100	0·00300	0·00600	$2{\cdot}17 \times 10^{-6}$
2	0·00100	0·00600	0·00600	$8{\cdot}68 \times 10^{-6}$
3	0·00050	0·00600	0·00600	$4{\cdot}34 \times 10^{-6}$
4	0·00300	0·00300	0·00300	$6{\cdot}51 \times 10^{-6}$

(Question continues on next page)

(i) Calculate the orders with respect to X, Y and Z. (3 marks)

X _____

Y _____

Z _____

(ii) Give the rate equation for the reaction and hence calculate the rate constant, k, to an appropriate number of significant figures. Include units in your answer. (4 marks)

(Question continues on next page)

(c) The kinetics of the 'bromine clock' were investigated and the rate equation was found to be

$$\text{Rate} = k[BrO_3^-][Br^-][H^+]^2$$

(i) What is the overall reaction order? (1 mark)

☐ A First

☐ B Second

☐ C Third

☐ D Fourth

(ii) Calculate the concentration of bromide ions required to produce a reaction rate of $4{\cdot}08 \times 10^{-3}$ mol dm^{-3} s^{-1} at 298 K given that

$$k = 8{\cdot}00\ dm^9\ mol^{-3}\ s^{-1}$$

$$[BrO_3^-] = 0{\cdot}200\ mol\ dm^{-3}$$

$$[H^+] = 0{\cdot}100\ mol\ dm^{-3}$$

(2 marks)

(Answer on next page)

(Question continues on next page)

(d) The rate constant for the reaction between bromoethane and aqueous hydroxide ions was determined at five different temperatures.

The results are given in the table.

Temperature (T) / K	1 / Temperature (1 / T) / K^{-1}	Rate constant, k / $dm^3 mol^{-1} s^{-1}$	ln k
293	$3{\cdot}41 \times 10^{-3}$	$5{\cdot}83 \times 10^{-5}$	–9·75
303		$1{\cdot}67 \times 10^{-4}$	
313		$5{\cdot}26 \times 10^{-4}$	
323		$1{\cdot}36 \times 10^{-3}$	
333	$3{\cdot}00 \times 10^{-3}$	$3{\cdot}77 \times 10^{-3}$	–5·58

(Question continues on next page)

Complete the data in the table and on the separate sheet provided use them to plot a graph of ln k against 1/T and hence determine the activation energy, E_a, in kJ mol^{-1}.

You should include the value and units of the gradient of the line.

The Arrhenius equation can be expressed as

$$\ln k = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant}$$

(7 marks)

(TOTAL FOR QUESTION 9 = 18 MARKS)

TOTAL FOR PAPER = 90 MARKS

END