



Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

Pearson Edexcel Level 3 GCE

Time 1 hour 45 minutes

Paper
reference

9CH0/02

Chemistry

Advanced

PAPER 2: Advanced Organic and Physical Chemistry

You must have:

Scientific calculator, Data Booklet, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
- *there may be more space than you need.*

Information

- 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 printed on the back cover of this paper.

Advice

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

Turn over ►

P67094RA

©2022 Pearson Education Ltd.

Q:1/1/1/1/1/1/



P 6 7 0 9 4 R A 0 1 2 4

www.ibworldwideacademy.com



Pearson

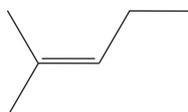


Answer ALL questions.

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 polymers.

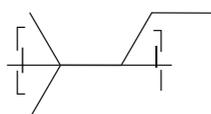
(a) An addition polymer is formed from 2-methylpent-2-ene.



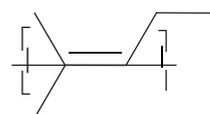
What is the repeat unit for poly(2-methylpent-2-ene)?

(1)

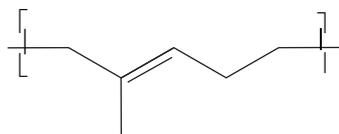
A



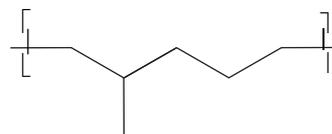
B



C



D



(b) Which is **not** a use of waste poly(alkenes)?

(1)

- A feedstock for cracking
- B generation of biodegradable materials
- C incineration to release energy
- D make new materials by recycling

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



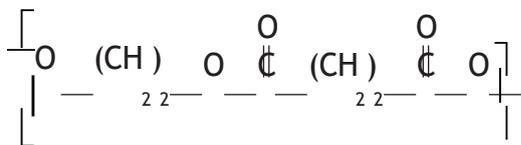


(c) A condensation polymer can be made from ethane-1,2-diol and butanedioic acid.

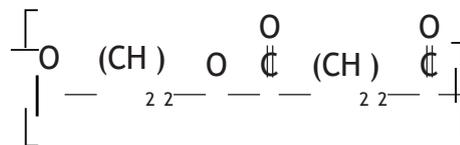
Which is the repeat unit for this polymer?

(1)

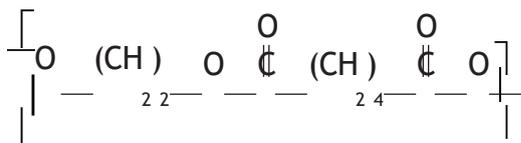
A



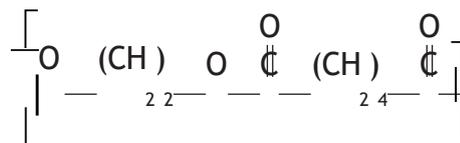
B



C



D



(d) Which approach used by chemists would **not** contribute to a more sustainable use of materials over the life cycle of a polymer?

(1)

- A** make more efficient use of energy
- B** make more efficient use of resources
- C** use catalysts for a faster reaction rate
- D** use a higher temperature for a faster reaction rate

(Total for Question 1 = 4 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA





2 This is a question about hydrocarbons.

(a) State what is meant by the term **hydrocarbon**.

(1)

.....

.....

(b) Explain why 2,2-dimethylpropane has a much lower boiling temperature than its isomer pentane.

Detailed descriptions of the forces involved are not required.

(2)

.....

.....

.....

.....

.....

.....

(c) The **heterolytic** bond fission of a sigma (σ) bond in an alkane would produce

(1)

- A only carbocations
- B only free radicals
- C free radicals and ions
- D ions

(Total for Question 2 = 4 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



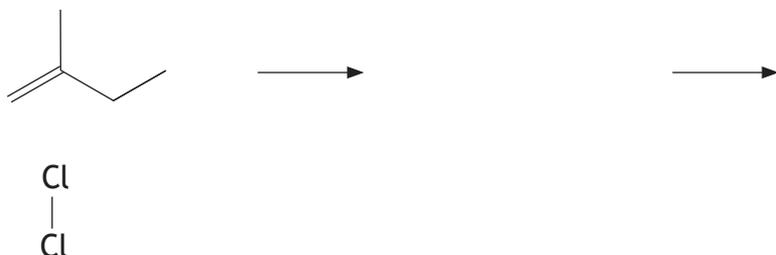


3 This is a question about dihalogenoalkanes.

(a) Dihalogenoalkanes are formed when alkenes react with halogens.

- (i) Complete the mechanism for the production of a dihalogenoalkane from 2-methylbut-1-ene and chlorine. Include curly arrows and any relevant lone pairs.

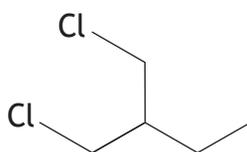
(3)



- (ii) Give the name of the dihalogenoalkane produced.

(1)

(b) What is the classification of the dihalogenoalkane shown?



(1)

- A primary
- B secondary
- C tertiary
- D primary and secondary

(Total for Question 3 = 5 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



4 This question is about nitrogen and some nitrogen compounds.

(a) A study of one brand of crisps found that each packet contained 0.420 g of nitrogen gas at a pressure of 120 kPa and a temperature of 20 °C.

(i) Calculate the volume of nitrogen gas, in **cm³**, in one packet of crisps.

$$[R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}]$$

(4)

(ii) Give a possible reason why nitrogen gas and not air is used in packets of crisps.

(1)

(b) Draw dot-and-cross diagrams for a molecule of nitrogen gas and for the nitride ion, N^{3-} , in sodium nitride, Na_3N .

Use dots (●) for nitrogen electrons and crosses (X) for electrons from sodium.

Nitrogen molecule

Nitride ion

(2)

DO NOT WRITE IN THIS AREA

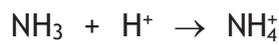
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA





(c) Ammonia accepts a proton to form an ammonium ion.



Explain why the ammonia molecule and the ammonium ion have different shapes and different bond angles.

(4)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

.....

.....

.....

.....

.....

(d) Butylamine, $\text{C}_4\text{H}_9\text{NH}_2$, reacts with ethanoyl chloride.



Explain how this equation illustrates that butylamine acts as a nucleophile and as a base.

(4)

DO NOT WRITE IN THIS AREA

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 4 = 15 marks)





5 Ice has a density of 0.92 g cm^{-3} and water has a density of 1.00 g cm^{-3} .

(a) About 200 cm^3 of water and 200 cm^3 of cooking oil were placed in a large beaker and two layers formed. The cooking oil formed the upper layer.

An ice cube made from water with a water-soluble blue food dye was added.

Initially the ice cube floated on top of the cooking oil but on melting the blue-coloured water sank into the bottom layer of water.

Give a possible value for the density of the cooking oil. Justify your answer.

(2)

.....

.....

.....

.....

.....

.....

(b) Calculate how many **more** molecules there are in 5.00 cm^3 of water compared to 5.00 cm^3 of ice.

(3)

(Total for Question 5 = 5 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



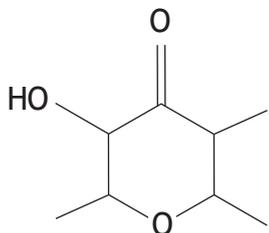


6 Aldehydes and ketones are carbonyl compounds.

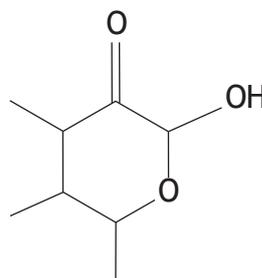
(a) Which of these compounds does **not** contain a ketone functional group?

(1)

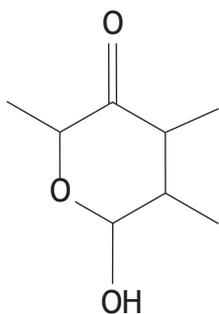
A



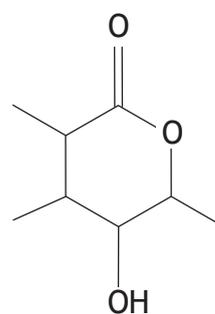
B



C



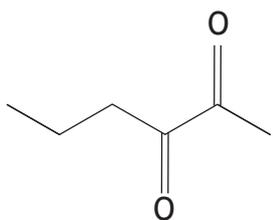
D



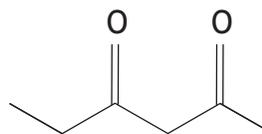
(b) Which of these compounds has both an aldehyde functional group **and** a ketone functional group?

(1)

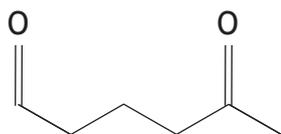
A



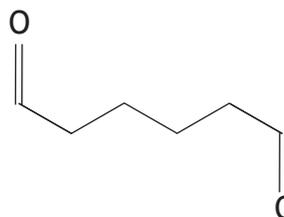
B



C



D



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA





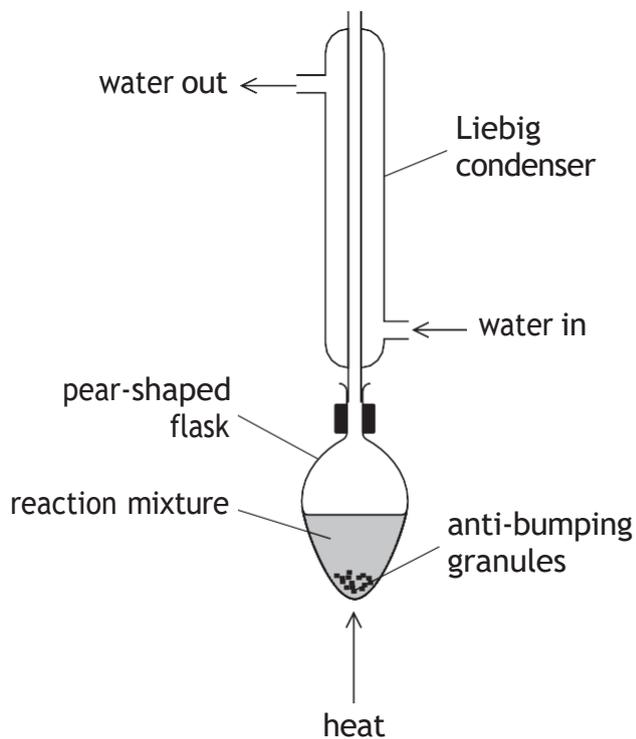
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c) Propanal can be produced from the oxidation of propan-1-ol.

(i) A student assembled the apparatus shown for this oxidation.



Explain why the use of this apparatus would give a very low yield of propanal.

(2)

.....

.....

.....

.....

(ii) The oxidising agent is acidified $\text{Na}_2\text{Cr}_2\text{O}_7$.

State the oxidation number of chromium in $\text{Na}_2\text{Cr}_2\text{O}_7$.

(1)

.....

(iii) Complete the ionic half-equation for the oxidation of propan-1-ol.

(1)





(iv) State how the use of anti-bumping granules gives smoother boiling.

(1)

.....

.....

.....

(v) Another student used the correct apparatus for this oxidation.
1.50 g of propan-1-ol produced 0.609 g of propanal.

Calculate the percentage yield of propanal by mass.

(3)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



P 6 7 0 9 4 R A 0 1 1 2 4



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(d) The table contains data on propanone and ethanoic acid.

Substance	Molar mass / g mol^{-1}	Boiling temperature / $^{\circ}\text{C}$	Solubility in water
Propanone	58	56	completely miscible
Ethanoic acid	60	118	completely miscible

(i) Explain, by reference to the data and any intermolecular forces involved, the difference in the boiling temperatures. (4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....





(ii) Explain, with the aid of a diagram, why propanone is completely miscible with water.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 6 = 16 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA





7 Organic compounds containing nitrogen include amides, amines, amino acids and nitriles.

(a) Propylamine, $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$, may be formed from either a nitrile or a halogenoalkane.

(i) Give the reagent and essential condition for the formation of propylamine from a nitrile.

Include an equation for the reaction.

(2)

(ii) Give the reagent and essential conditions for the formation of propylamine from a halogenoalkane.

Include an equation for the reaction.

(3)

(b) A compound produced a peak due to an N-H stretching vibration in its infrared spectrum with a wavenumber of 3220 cm^{-1} .

This compound could be

(1)

- A an amide
- B an amine
- C either an amide or an amine
- D neither an amide nor an amine

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



P 6 7 0 9 4 R A 0 1 1 2 4



*(c) Alanine and glycine are amino acids.

Amino acid	Structure
alanine	$\begin{array}{c} \text{H} & & \text{CH}_3 & & \text{O} \\ & \diagdown & & / & // \\ & \text{N} & - \text{C} & - & \text{C} \\ & / & & & \backslash \\ \text{H} & & \text{H} & & \text{O}-\text{H} \end{array}$
glycine	$\begin{array}{c} \text{H} & & \text{H} & & \text{O} \\ & \diagdown & & / & // \\ & \text{N} & - \text{C} & - & \text{C} \\ & / & & & \backslash \\ \text{H} & & \text{H} & & \text{O}-\text{H} \end{array}$

Compare and contrast the structures, optical activity and reactions with acids and bases of alanine and glycine.

Include diagrams, structures and equations to illustrate your answer.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA





DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Main writing area with horizontal dashed lines.





(d) Lysine and serine are two more amino acids.

Amino acid	Structure of amino acid
lysine	$\begin{array}{c} \text{NH}_2 \\ \\ (\text{CH}_2)_4 \\ \\ \text{H} \quad \text{N} - \text{C} - \text{C} \begin{array}{l} // \text{O} \\ \backslash \text{O}-\text{H} \end{array} \\ \\ \text{H} \end{array}$
serine	$\begin{array}{c} \text{OH} \\ \\ \text{CH}_2 \\ \\ \text{H} \quad \text{N} - \text{C} - \text{C} \begin{array}{l} // \text{O} \\ \backslash \text{O}-\text{H} \end{array} \\ \\ \text{H} \end{array}$

Explain the difference in the volumes of $0.010 \text{ mol dm}^{-3}$ hydrochloric acid required to completely react with separate 10.0 cm^3 samples of aqueous lysine and of aqueous serine, both of concentration $0.010 \text{ mol dm}^{-3}$.

(2)

.....

.....

.....

.....

.....

(Total for Question 7 = 14 marks)

DO NOT WRITE IN THIS AREA

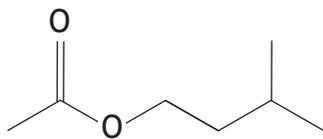
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

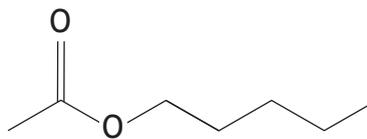




- 8 Esters have many uses due to their characteristic aromas and often have common names. For example, isoamyl acetate is referred to as banana oil and amyl acetate has a scent similar to apples.



isoamyl acetate



amyl acetate

- (a) What is the number of peaks in a ^{13}C NMR spectrum of isoamyl acetate and of amyl acetate?

(1)

	isoamyl acetate	amyl acetate
<input type="checkbox"/> A	5	6
<input type="checkbox"/> B	6	6
<input type="checkbox"/> C	6	7
<input type="checkbox"/> D	7	7

- (b) State the molecular formula of amyl acetate.

(1)

- (c) Deduce the structural formula of the carboxylic acid that could be used to form both isoamyl acetate and amyl acetate.

(1)

- (d) Deduce the **name** of the alcohol that forms isoamyl acetate.

(1)

- (e) Give the systematic name for amyl acetate.

(1)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA





(f) The carboxylic acid used to make isoamyl acetate and amyl acetate can also be used to make six further ester isomers. The structures of two of these esters, **A** and **B**, are shown.

(i) Complete the **skeletal** formulae of **three** of the remaining esters. Names are **not** required.

(3)

<p>isoamyl acetate</p>	<p>amyl acetate</p>	
<p>ester A</p>		
<p>ester B</p>		

(ii) Write an equation to show the formation of ester **A** from an acyl chloride and an alcohol.

(2)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



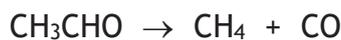


DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

9 At high temperatures, ethanal decomposes to form methane and carbon monoxide. The reaction is second order with respect to ethanal and second order overall.



(a) Write the rate equation for this reaction. (1)

(b) Deduce the units of the rate constant given that the units of rate are $\text{mol dm}^{-3} \text{s}^{-1}$. (1)

(c) The table shows the concentration of ethanal in a sample at different times.

Time / s	Concentration of ethanal / mol dm^{-3}
0	0.72
420	0.36
1260	0.18

Calculate average values for the rate of reaction between 0 and 420 seconds and between 420 and 1260 seconds.

Give your answers to an appropriate number of significant figures. (2)

0s - 420s

420s - 1260s





DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(d) Explain why the data given and your answers in (c) show that the reaction is **neither** zero order **nor** first order.

(2)

.....

.....

.....

.....

.....

.....

(e) The rate constant for the reaction was determined at five temperatures. The results are given in the table.

Temperature (T) / K	1/ Temperature ($1/T$) / K^{-1}	Rate constant (k) / units in (b)	$\ln k$
700	1.43×10^{-3}	0.011	-4.51
730	1.37×10^{-3}	0.035	-3.35
760	1.32×10^{-3}	0.105	-2.25
790		0.343	
810	1.23×10^{-3}	0.787	-0.24

Determine the activation energy, E_a , in kJ mol^{-1} , by completing the data in the table and plotting a graph of $\ln k$ against $1/T$.

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

The Arrhenius equation can be expressed as $\ln k = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant}$

(7)



