GCE AS LEVEL CHEMISTRY

S21- B410

Assessment Resource A

Energy, Rate and Carbon Compounds

1. Ethanol is produced industrially by hydration of ethene. The reaction is typically carried out using a catalyst at 300 °C and 70 atm pressure.

Name the catalyst used in this reaction. [1]

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2. But-2-ene can exist as *E*- and *Z*- isomers.

(a) Draw the **skeletal** formula for *Z*-but-2-ene. [1]

(b) Explain why but-2-ene can form *E*- and *Z*- isomers but but-1-ene cannot. [2]

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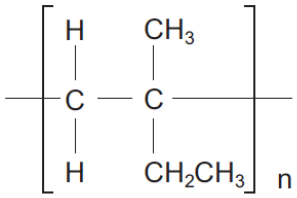
3. Name the alkene monomer that can be polymerised to give the following polymer. [1]



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4. *(a)* Alkanes are derived from petroleum and many are used as fuels. Some of the compounds found in petroleum contain sulfur.

State and explain **one** reason why sulfur compounds should be removed from fuels before they are used. [2]

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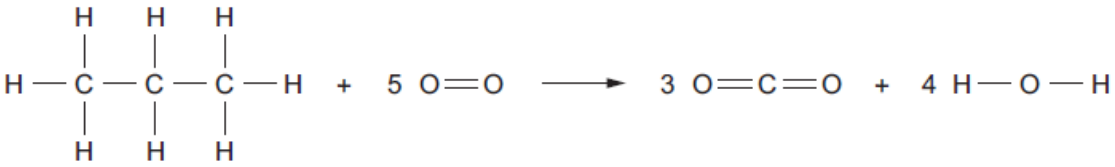
(b) Propane is a constituent of liquefied petroleum gas (LPG). Propane burns in air to form carbon dioxide and water. The equation for the reaction is as follows.



The enthalpy change for the reaction is $-1690\,kJ\,mol^{-1}$.

Use this and the data given in the table below to calculate the average bond enthalpy for the C—H bond. [3]

Bond	Average bond enthalpy / $kJ\,mol^{-1}$
C—C	348
O—H	463
O=O	496
C=O	743

C—H bond enthalpy = ... $kJ\,mol^{-1}$

(c) When methane and chlorine are combined in sunlight a reaction occurs with chloromethane formed as the main organic product.

(i) Name the type of reaction mechanism which occurs in this case. [1]

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(ii) Write the mechanism for this reaction to form chloromethane. Include one termination step. [4]

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(d) Butane is another common alkane. Two other compounds with a similar molecular mass to butane are ethanoic acid and propan-1-ol.

The boiling temperatures in °C for butane, ethanoic acid and propan-1-ol are

–1, 97 and 118, **but not necessarily in that order**.

Deduce the boiling temperature of **each** compound, giving reasons in support of your conclusions. [3]

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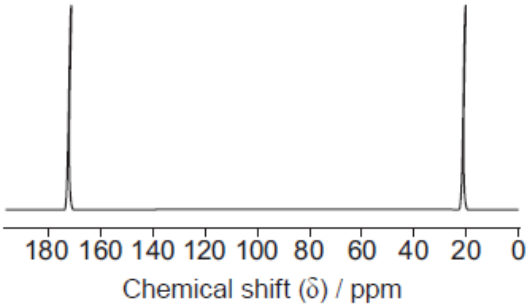
(e) Compounds **A** and **B** are two of butane, ethanoic acid and propan-1-ol.

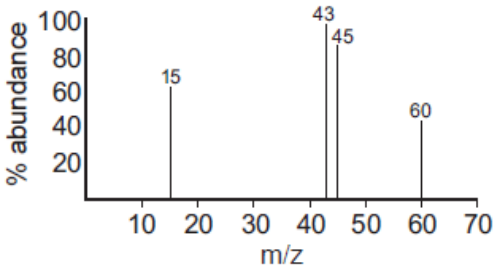
Their ^{13}C NMR spectra and simplified mass spectra are shown below.

Compound **A**

^{13}C NMR spectrum

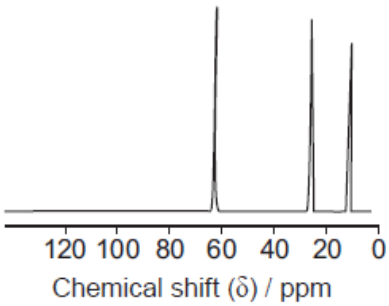


Mass spectrum

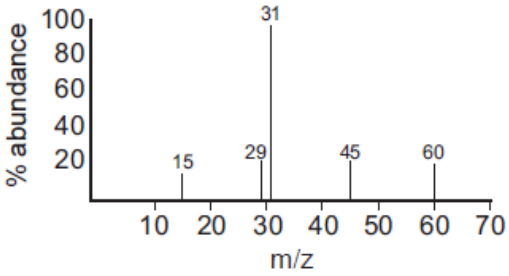


Compound **B**

^{13}C NMR spectrum



Mass spectrum



Use the information to identify compounds **A** and **B** clearly explaining your reasoning. Describe the main features that would be seen in the ^{13}C NMR spectrum and the mass spectrum of the **remaining** compound. [6 QER]

(f) State and explain how you would expect the infrared spectrum of ethanoic acid to differ from that of propan-1-ol. [2]

5. Hydrogen peroxide reacts with iodide ions in acid solution to produce iodine. The equation for the reaction is as follows.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \longrightarrow I_2(aq) + 2H_2O(l)$$

A student is asked to investigate the effect of changing the concentration of hydrogen peroxide on the rate of reaction by a "clock method".

She is told to carry out the following method.

- Measure 10.0 cm^3 of sulfuric acid, 10.0 cm^3 of sodium thiosulfate, 15.0 cm^3 of potassium iodide and 1.0 cm^3 of starch solution into a conical flask.
- Measure 5.0 cm^3 of hydrogen peroxide and 9.0 cm^3 of water into a boiling tube.
- Add the peroxide solution to the other reagents in the flask and start a stopwatch at the same time.
- Record the time taken, to the nearest second, for a blue-black colour to form in the reaction mixture.
- Repeat the procedure five times, with each run differing only in the peroxide concentration in the mixture, ensuring that the reaction times are neither too short nor too long.

She obtains the following results.

Experiment	Volume H_2O_2 / cm^3	Volume H_2O / cm^3	Time / s	$\frac{1}{\text{Time}}$ / s^{-1}
1	5.0	9.0	28	0.0357
2	6.0	8.0		
3	7.0	7.0	17	0.0589
4	4.0	10.0	36	0.0278
5	3.0	11.0	54	0.0185
6	2.0	12.0	102	0.0098

(a) The student says that it would be better to make up a single batch containing the acid, thiosulfate, iodide and starch solutions in the correct proportions before starting and use 36.0 cm^3 of this in each experiment. Is she correct? Justify your answer. [1]

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(b) State **two** changes which could be made in order to improve the results in this experiment. Explain your reason in each case. [4]

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(c) Give a reason why the peroxide is measured into a boiling tube first and not added directly to the flask from a burette. [1]

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(d) Suggest a reason why the student did not carry out the procedure using 8.0 cm^3 of hydrogen peroxide and 6.0 cm^3 of water. [1]

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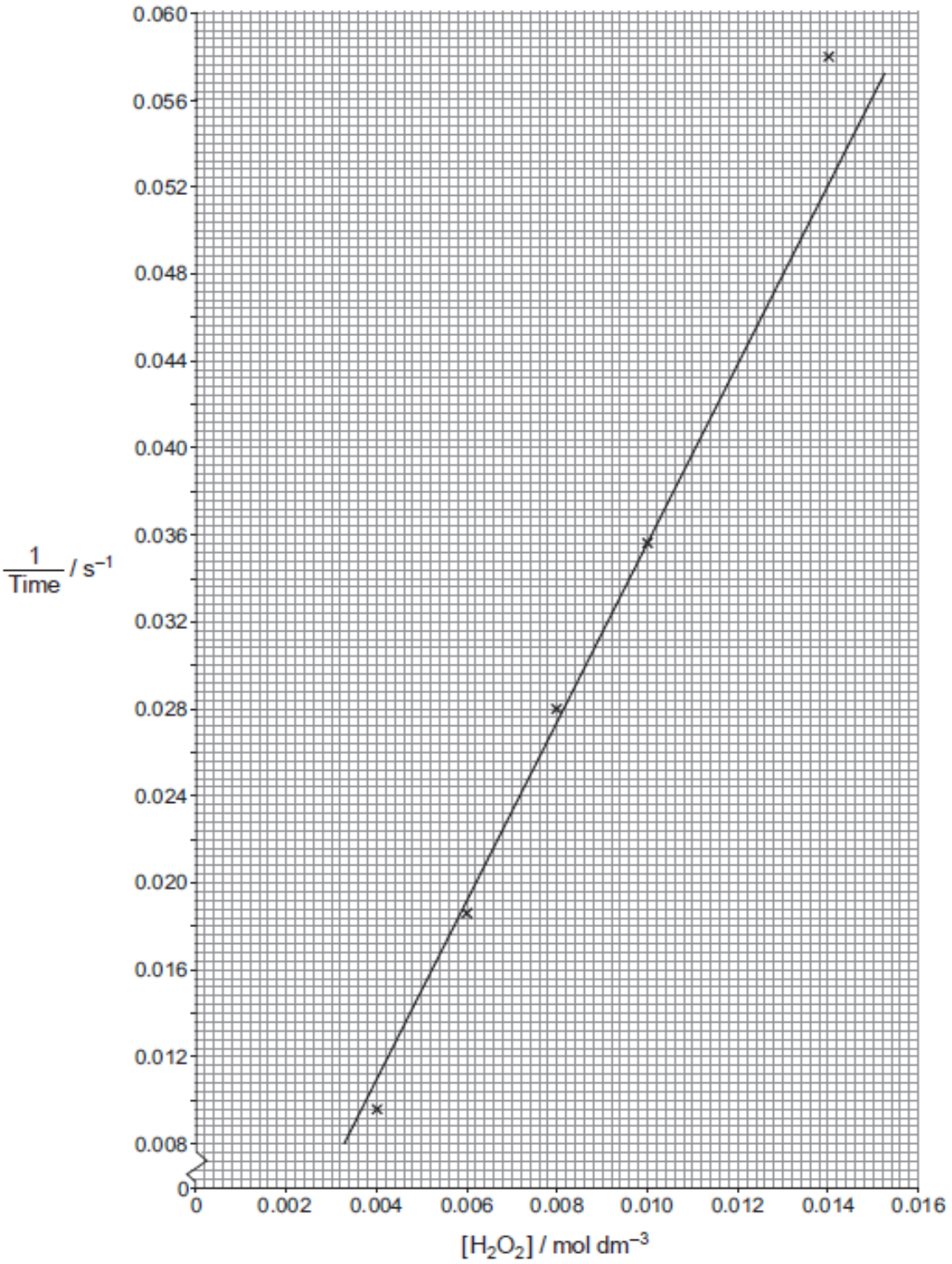
(e) She plotted a graph of rate against concentration of peroxide. This is shown below.



(i) State how the rate depends on the concentration of peroxide. [1]

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(ii) Use the graph to find the time taken for the colour change to occur when she used 6.0 cm^3 of hydrogen peroxide and 8.0 cm^3 of water. [2]

Time = ... s

(f) Suggest another method, not using sodium thiosulfate, by which the rate of this oxidation reaction could be measured. [2]

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(g) Explain, using simple collision theory, why the rate of this reaction changes as the concentration of hydrogen peroxide changes. [2]

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