1 The alcohols form a homologous series. The first five members are given in the table below.

(a)

alcohol	formula	heat of combustion in kJ / mol
methanol	CH_3OH	730
ethanol	$CH_3–CH_2–OH$	1380
propan-1-ol		
butan-1-ol	$CH_3–CH_2–CH_2–CH_2–OH$	2680
pentan-1-ol	$CH_3–CH_2–CH_2–CH_2–CH_2–OH$	3350

(i) Complete the table. [2]

(ii) Complete the equation for the combustion of pentan-1-ol in excess oxygen.

$$C_5H_{11}OH + ...O_2 \rightarrow ..... + ...$$ [1]

(b) State **three** characteristics of a homologous series other than the variation of physical properties down the series.

.....

.....

..... [3]

(c) The following alcohols are isomers.

$$CH_3–CH_2–CH_2–CH_2–OH \quad \text{and} \quad (CH_3)_2CH–CH_2–OH$$

(i) Explain why they are isomers.

.....

.....

..... [2]

(ii) Draw the structural formula of another isomer of the above alcohols.

[1]

(d) Alcohols can be made by fermentation and from petroleum.

(i) Ethanol is made from sugars by fermentation.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

The mass of one mole of glucose, $C_6H_{12}O_6$, is 180 g.
Calculate the maximum mass of ethanol which could be obtained from 72 g of glucose.

.....

.....

.....

..... [3]

(ii) Describe how ethanol is made from petroleum.

petroleum (alkanes) → ethene → ethanol

.....

.....

.....

..... [3]

[Total: 15]

2 The Carlsbad caverns in New Mexico are very large underground caves. Although the walls of these caves are coated with gypsum (hydrated calcium sulphate), the caves have been formed in limestone.

(a) It is believed that the caves were formed by sulphuric acid reacting with the limestone.

(i) Complete the word equation.

calcium carbonate + sulphuric acid ⟶ calcium sulphate + ... + ...

[1]

(ii) Describe how you could test the water entering the cave to show that it contained sulphate ions.

test .....

result ..... [2]

(iii) How could you show that the water entering the cave has a high concentration of hydrogen ions?

..... [1]

(b) Hydrogen sulphide gas which was escaping from nearby petroleum deposits was being oxidised to sulphuric acid.

(i) Complete the equation for this reaction forming sulphuric acid.

H_2S + ... O_2 ⟶ ..... [2]

(ii) Explain why all the hydrogen sulphide should be removed from the petroleum before it is used as a fuel.

.....

..... [1]

(iii) Draw a diagram to show the arrangement of the valency electrons in one molecule of the covalent compound hydrogen sulphide.
Use o to represent an electron from a sulphur atom.
Use x to represent an electron from a hydrogen atom.

[2]

(c) Sulphuric acid is manufactured by the Contact Process. Sulphur dioxide is oxidised to sulphur trioxide by oxygen.

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

(i) Name the catalyst used in this reaction.

..... [1]

(ii) What temperature is used for this reaction?

..... [1]

(iii) Describe how sulphur trioxide is changed into sulphuric acid.

.....

..... [2]

(d) Gypsum is hydrated calcium sulphate, $CaSO_4.xH_2O$. It contains 20.9% water by mass. Calculate x.

M_r: $CaSO_4$, 136; H_2O, 18.

79.1 g of $CaSO_4$ = ... moles

20.9 g of H_2O = ... moles

x = ... [3]

3 Some of the factors that can determine the rate of a reaction are concentration, temperature and light intensity.

(a) A small piece of calcium carbonate was added to an excess of hydrochloric acid. The time taken for the carbonate to react completely was measured.

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The experiment was repeated at the same temperature, using pieces of calcium carbonate of the same size but with acid of a different concentration. In all the experiments an excess of acid was used.

concentration of acid / mol dm^{-3}	4	2	2	…….
number of pieces of carbonate	1	1		
time / s	…….	80	…….	160

(i) Complete the table (assume the rate is proportional to both the acid concentration and the number of pieces of calcium carbonate). [3]

(ii) Explain why the reaction rate would increase if the temperature was increased.

.....

.....[2]

(iii) Explain why the rate of this reaction increases if the piece of carbonate is crushed to a powder.

.....[1]

(iv) Fine powders mixed with air can explode violently. Name an industrial process where there is a risk of this type of explosion.

.....

.....[1]

(b) Sodium chlorate(I) decomposes to form oxygen and sodium chloride. This is an example of a photochemical reaction. The rate of reaction depends on the intensity of the light.

$$2NaClO(aq) \longrightarrow 2NaCl(aq) + O_2(g)$$

(i) Describe how the rate of this reaction could be measured.

.....

.....[2]

(ii) How could you show that this reaction is photochemical?

.....

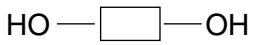
.....[1]

(c) Photosynthesis is another example of a photochemical reaction. Glucose and more complex carbohydrates are made from carbon dioxide and water.

(i) Complete the equation.

$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 +$ …….. [2]

(ii) Glucose can be represented as



Draw the structure of a more complex carbohydrate that can be formed from glucose by condensation polymerisation.

[2]

4 The alcohols form an homologous series.

(a) Give **three** characteristics of an homologous series.

.....

.....

.....

..... [3]

(b) The following two alcohols are members of an homologous series and they are isomers.

$CH_3 — CH_2 — CH_2 — CH_2 — OH$ and $(CH_3)_2CH — CH_2 — OH$

(i) Explain why they are isomers.

.....

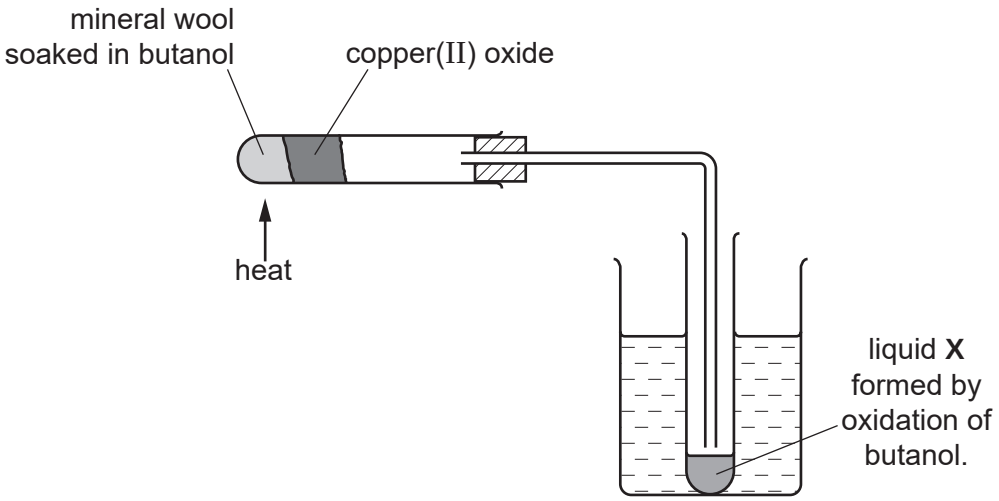
.....

..... [2]

(ii) Deduce the structural formula of another alcohol which is also an isomer of these alcohols.

[1]

(c) Copper(II) oxide can oxidise butanol to liquid **X**, whose pH is 4.



(i) Give the name of another reagent which can oxidise butanol.

.....

[1]

(ii) Which homologous series does liquid **X** belong to?

.....

[1]

(iii) State the formula of liquid **X**.

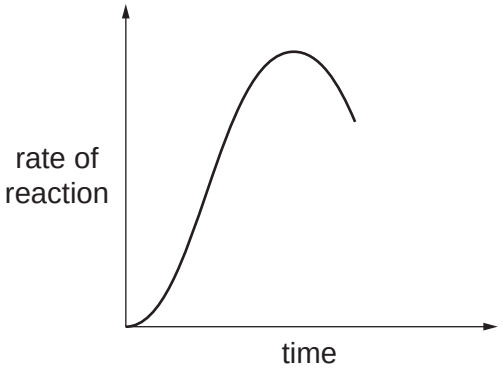
.....

[1]

(d) The alcohol ethanol can be made by fermentation. Yeast is added to aqueous glucose.

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

Carbon dioxide is given off and the mixture becomes warm, as the reaction is exothermic. The graph shows how the rate of reaction varies over several days.



(i) Suggest a method of measuring the rate of this reaction.

.....

..... [2]

(ii) Why does the rate initially increase?

.....

..... [1]

(iii) Suggest **two** reasons why the rate eventually decreases.

.....

..... [2]

[Total: 14]