1 An industrial chemical company has supplies of ethene and ethanol.

The company considers using these two processes.

process 1 converting ethene to ethanol

process 2 converting ethanol to ethene

A chemical equation for process 1 is

$$C_2H_4 + H_2O \rightarrow C_2H_6O$$

(a) Which condition does the chemical company use in process 1?

(1)

☒ **A** aluminium oxide as a catalyst

☒ **B** a pressure of 65 atm

☒ **C** a temperature of 1000 °C

☒ **D** sodium hydroxide as a solvent

(b) The equation for process 1 shows the molecular formulae of ethene and ethanol.

Draw the displayed formulae of ethene and ethanol.

(2)

Compound	Displayed formula
ethene	
ethanol	

(c) Why is it correct to describe ethanol as saturated, but incorrect to describe it as a hydrocarbon?

(2)

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(d) A scientist working for the chemical company makes the following predictions that could affect processes 1 and 2 in the future:

- crude oil will be less available and more expensive
- the climate will be warmer and allow more sugar cane to be grown

Suggest how each of these predictions would affect the two processes.

(3)

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(Total for Question 1 = 8 marks)

2 (a) Wine can be made from grapes.

The grapes are crushed to produce an aqueous solution containing glucose. Yeast is then added to this solution.

The solution is kept at a constant temperature for a period of time. The glucose is converted into ethanol.

(i) Name the process in which glucose is converted into ethanol.

(1)

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(ii) What is the purpose of the yeast?

(1)

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(b) Grape vines can be attacked by a fungus that ruins the grapes. The fungus can be killed using Bordeaux mixture, a solid containing copper(II) sulfate and calcium hydroxide.

(i) State a test to show that Bordeaux mixture contains calcium ions.

(2)

test for calcium ions .....

observation .....

(ii) A sample of Bordeaux mixture is dissolved in water.

Describe separate tests to show that this solution contains copper(II) ions and sulfate ions.

(5)

test for copper(II) ions .....

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observation .....

test for sulfate ions.....

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observation.....

(c) Ethanol can be manufactured by passing a hot mixture of ethene and steam, at a high pressure, over a catalyst.

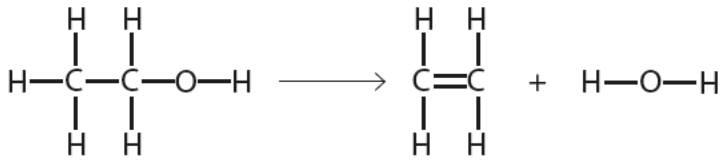
State the pressure used and name the catalyst.

(2)

pressure ..... atm

catalyst .....

(d) The equation for the conversion of ethanol into ethene can be written using displayed formulae.



The table gives some average bond energies.

Bond	Average bond energy in kJ/mol
C—C	348
C=C	612
C—H	412
C—O	360
O—H	463

Use information from the table to calculate the enthalpy change, in kJ/mol, for the conversion of ethanol into ethene.

(4)

enthalpy change = ... kJ/mol

(Total for Question 2 = 15 marks)

3 This is a recipe for making plum wine.

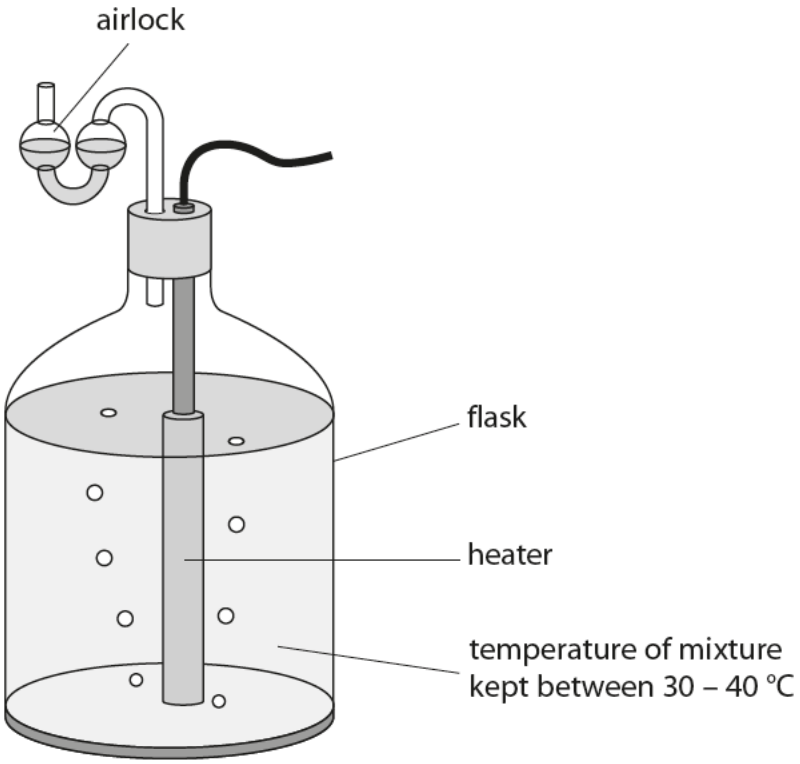
Dissolve 1.5 kg of sugar in 5 dm^3 of warm water.

Add yeast and 8 kg of plums.

Pour the mixture into a flask.

Leave the flask for several weeks until the reaction has stopped.

Remove the solid yeast and pour the clear liquid into bottles.



(a) Sugar contains sucrose, $C_{12}H_{22}O_{11}$

When yeast is added, water reacts with sucrose to form glucose, $C_6H_{12}O_6$

Write a chemical equation for this reaction.

(1)

(b) The glucose is then converted into ethanol by the yeast

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

(i) How would you know when the reaction has stopped?

(1)

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(ii) How could the solid yeast be removed from the mixture?

(1)

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(c) Ethanol can be converted into chloroethene, $CH_2{=}CHCl$, in three stages.

Stage 1 Ethanol is dehydrated to form ethene, $CH_2{=}CH_2$

Stage 2 Ethene is converted into 1,2-dichloroethane, CH_2ClCH_2Cl

Stage 3 1,2-dichloroethane is converted into chloroethene and hydrogen chloride

(i) Why is the reaction in **Stage 1** described as dehydration?

(1)

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(ii) Identify the catalyst used in the reaction in **Stage 1**.

(1)

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(iii) Suggest the name or formula of the substance used to react with ethene in **Stage 2**.

(1)

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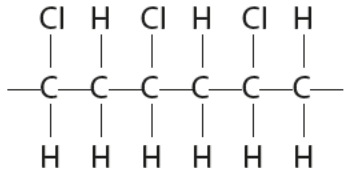
(iv) Write a chemical equation for the reaction in **Stage 3**.

(1)

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(d) Chloroethene can be used to make the polymer poly(chloroethene), also known as PVC.

The displayed formula for part of the PVC molecule is



(i) Draw a displayed formula for a chloroethene molecule.

(1)

(ii) Describe, in terms of structure and bonding, what happens when chloroethene molecules are converted into poly(chloroethene).

(3)

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(Total for Question 3 = 11 marks)

4 Fractional distillation and cracking are important steps in processing crude oil.

(a) Place ticks (✓) in the columns to show which statements apply to each step.
You may place a tick in one column, in both columns or in neither column.

The first one has been done for you.

(5)

Statement	Fractional distillation	Cracking
Crude oil is heated	✓	
A catalyst may be used		
Alkenes are formed		
Decomposition reactions occur		
Fuels are obtained		
Separation is the main purpose		

(b) The formula $CH_3CH_2CH_2CH_2CH_3$ represents one of the compounds in crude oil.

(i) Give the molecular formula of this compound.

(1)

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(ii) Give the displayed formula of this compound.

(1)

(iii) Give the empirical formula of this compound.

(1)

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(iv) Give the name of this compound.

(1)

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(v) Give the general formula of the homologous series that contains this compound.

(1)

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(c) The products of the complete combustion of hydrocarbons are carbon dioxide and water.

(i) Balance the equation to show the complete combustion of ethene (C_2H_4).

(2)

$$C_2H_4 + \ldots\ldots O_2 \rightarrow \ldots\ldots CO_2 + \ldots\ldots H_2O$$

(ii) Draw a dot and cross diagram to show the bonding in an ethene molecule.

Show only the outer electrons in each atom.

(2)

(d) Ethanol can be manufactured by the hydration of ethene. The equation for this reaction is

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$$

(i) Identify the catalyst and state the temperature used in this process.

(2)

Catalyst .....

Temperature .....

(ii) A 20 mol sample of ethanol was produced using this reaction.

Deduce the amount, in moles, of ethene needed and the volume, in dm^3, that this amount of ethene would occupy at room temperature and pressure.

Assume that all of the ethene is converted into ethanol and that the molar volume of ethene is 24 dm^3 at rtp.

(3)

Amount of ethene ..... mol

Volume of ethene

Volume = ... dm^3

(Total for Question 4 = 19 marks)