1 Stowmarket Synthetics manufacture ethanoic acid, $C_2H_4O_2$, by two different processes.

Process **1** $C_2H_6O + O_2 \rightarrow C_2H_4O_2 + H_2O$

Process **2** $CH_4O + CO \rightarrow C_2H_4O_2$

Look at the table of relative formula masses.

Compound	Formula	Relative formula mass, M_r
ethanol	C_2H_6O	46
oxygen	O_2	32
ethanoic acid	$C_2H_4O_2$	60
water	H_2O	18
methanol	CH_4O	32
carbon monoxide	CO	28

The relative atomic mass of H = 1, of C = 12, and of O = 16.

(a) In process **2**, Stowmarket Synthetics use 320 g of methanol.

Calculate the maximum mass of ethanoic acid that can be made.

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..... **[2]**

(b) Stowmarket Synthetics know that the **atom economy** of a process is important.

Water is a waste product in process **1**.

Show that the atom economy for making ethanoic acid by process **1** is 77%.

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..... **[2]**

(c) Stowmarket Synthetics also know that the **percentage yield** of a process is important.

The factory uses 5.2 tonnes of methanol in process **2**.

A scientist predicts they should make 9.8 tonnes of ethanoic acid.

They actually make 9.5 tonnes of ethanoic acid.

Show that the percentage yield of ethanoic acid is 97%.

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..... **[2]**

(d) Look at the table.

It gives information about the atom economy and percentage yield for making ethanoic acid.

Process	Atom economy (%)	Percentage yield (%)
1	77	85
2	100	97

Process **2** has a higher atom economy and a higher percentage yield.

(i) Explain one advantage, other than cost, of a very high atom economy.

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..... **[1]**

(ii) Explain one advantage, other than cost, of a very high percentage yield.

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..... **[1]**

[Total: 8]

2 John and Sue are building a new house.



They want to choose the best fuel for their house.

They find out some information about four possible fuels.

fuel	is it easy to use?	annual cost to heat the house in £	is it available to this house?
coal	no	750	yes
LPG	yes	972	yes
natural gas	yes	720	no
oil	yes	750	yes

(a) Which fuel should John and Sue choose?

Explain your choice.

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..... **[2]**

(b) LPG contains propane gas, C_3H_8.

Write a **balanced symbol** equation for the complete combustion of propane in oxygen, O_2.

..... **[2]**

[Total: 4]

3 This question is about industrial processes.

(a) An industrial process makes sulfur trioxide.

Sulfur dioxide, SO_2, reacts with oxygen, O_2.

Sulfur trioxide, SO_3, is made.

Write the **balanced symbol** equation for this reaction.

..... **[2]**

(b) A second industrial process makes an acid.

Look at the table. It shows the percentage yield of the acid made at different temperatures and pressures.

pressure in atmospheres	percentage yield at 200 °C	percentage yield at 400 °C	percentage yield at 600 °C
100	80%	22%	8%
200	92%	40%	14%
300	95%	56%	18%
400	96%	67%	22%

(i) How does **increasing** the **temperature** change the percentage yield?

..... **[1]**

(ii) A temperature of 400 °C, a pressure of 200 atmospheres and a catalyst are used to make the acid.

These conditions do not give the highest percentage yield.

Suggest why these conditions are chosen.

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..... **[3]**

[Total: 6]