**5** Ethanoic acid is manufactured in the reaction between methanol and carbon monoxide.

An equilibrium mixture is produced.

$$CH_3OH(g) + CO(g) \rightleftharpoons CH_3COOH(g)$$

**(a)** State **two** characteristics of an equilibrium.

1 .....

2 .....

[2]

**(b)** Both a high yield of ethanoic acid and a high rate of reaction are needed.

The reaction is carried out at 300 °C.

The forward reaction is exothermic.

**(i)** State the disadvantage of using a temperature:

- below 300 °C

.....

- above 300 °C.

.....

[2]

**(ii)** Complete Table 5.1 using **only** the words **increases**, **decreases** or **no change**.

**Table 5.1**

| | effect on the equilibrium concentration of $CH_3COOH(g)$ | effect on the rate of the forward reaction |
|---|---|---|
| catalyst is added | | increases |
| pressure is increased | | |

[3]

**(iii)** Suggest which element from the list is a suitable catalyst for the reaction.

Give a reason for your answer.

**aluminium** **carbon** **cobalt** **magnesium** **sodium**

catalyst .....

reason .....

[2]

**(c)** Ethanoic acid is a member of the carboxylic acid homologous series.

**(i)** Name the carboxylic acid that contains only one carbon atom.

..... [1]

**(ii)** State the molecular formula of a carboxylic acid that contains four carbon atoms.

..... [1]

**(ii)** Propyl butanoate is an ester.

Name the carboxylic acid and alcohol that react to produce propyl butanoate.

carboxylic acid .....

alcohol .....

[2]

**(e)** An organic compound has the following composition by mass:

C, 58.82%; H, 9.80%; O, 31.38%.

Calculate the empirical formula of the compound.

empirical formula = ..... [3]

[Total: 18]