3 Alkenes undergo an addition reaction with a 1:1 mixture of CO and H_2 to form aldehydes.

Fig. 3.1 shows the reaction of propene with a 1:1 mixture of CO and H_2.

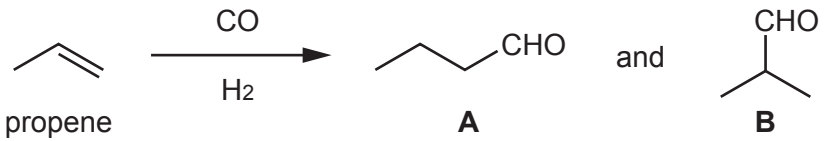

Fig. 3.1

(a) (i) Define addition reaction.

.....

..... [1]

(ii) Aldehydes **A** and **B** are structural isomers.

State the type of structural isomerism shown by **A** and **B**.

..... [1]

(iii) Name **A**.

..... [1]

(iv) The complete reaction of propene with a 1:1 mixture of CO and H_2 produces **A** and **B** only. The product mixture contains 96% **A** and 4% **B**.

Calculate the mass of **A** produced in this reaction when 5.00×10^3 kg of propene is used.

mass of **A** = ... kg [1]

(b) **A** and **B** show reactions typical of aliphatic aldehydes.

(i) **A** undergoes a nucleophilic addition reaction with a mixture of HCN and KCN, forming compound **C**.

Complete the diagram to show the mechanism for this reaction.

Include charges, dipoles, lone pairs of electrons and curly arrows, as appropriate.

Draw the structure of the organic intermediate.

[4]

(ii) Table 3.1 shows information about three experiments involving **B**.

Complete Table 3.1.

Table 3.1

experiment	reagents	observation with **B**
1		solution turns from orange to green
2		a silver mirror forms on the sides of the reaction vessel
3	$Br_2(aq)$	

[3]

(iii) **B**, C_4H_8O, is oxidised by acidified potassium manganate(VII).

Complete the equation for this reaction. Use [O] to represent one atom of oxygen from the oxidising agent.

C_4H_8O + ... [1]

(iv) **C** is a chiral molecule.

Circle any chiral centres in the structure of **C** shown in Fig. 3.2.

C

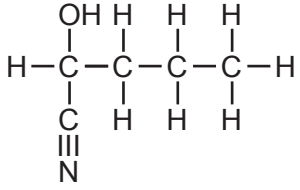

Fig. 3.2

[1]

(c) When propene reacts with CO and an excess of H_2, an alkane and a mixture of alcohols are formed instead. The alcohols are isomers of each other.

Suggest the molecular formulae of the alkane and the alcohols that are formed under these conditions.

molecular formula of alkane .....

molecular formula of alcohols .....

[2]

(d) The reaction of ethene, C_2H_4, with a 1:1 mixture of CO and H_2 is shown in equation 1.

equation 1 $C_2H_4(g) + CO(g) + H_2(g) \rightleftharpoons CH_3CH_2CHO(g)$

At atmospheric pressure a cobalt-based catalyst is used in this reaction.

(i) State and explain the effect of using a catalyst on this reaction.

.....

.....

.....

..... [2]

(ii) Explain why the yield of $CH_3CH_2CHO(g)$ increases when the overall pressure of the reaction mixture is increased.

.....

..... [1]

(iii) Use the information in Table 3.2 to calculate the enthalpy change, ΔH_r, of the reaction in equation 1.

equation 1 $\quad C_2H_4(g) + CO(g) + H_2(g) \rightleftharpoons CH_3CH_2CHO(g)$

Table 3.2

compound	enthalpy change of formation, ΔH_f / kJ mol^{-1}
$C_2H_4(g)$	+52
$CO(g)$	–111
$CH_3CH_2CHO(g)$	–187

ΔH_r = ... kJ mol^{-1} [2]

(iv) The reaction mixture is cooled to collect CH_3CH_2CHO as a liquid.

Identify all types of van der Waals' forces that are present between molecules of CH_3CH_2CHO.

.....

..... [1]

[Total: 21]