4. Alcohols and carboxylic acids are used in many laboratory experiments.

(a) Alcohols can take part in combustion reactions.

(i) Balance the equation for the enthalpy of combustion of propan-1-ol. **1**

$$C_3H_7OH \quad + \quad O_2 \quad \rightarrow \quad CO_2 \quad + \quad H_2O$$

(ii) An experiment was carried out to determine the enthalpy of combustion of propan-1-ol. The results are shown in the table.

Volume of water heated (cm^3)	150
Initial temperature of water (°C)	21.2
Final temperature of water (°C)	35.1
Mass of propan-1-ol burned (g)	0.498
Mass of one mole of propan-1-ol (g)	60

Calculate the enthalpy of combustion of propan-1-ol, in $kJ\,mol^{-1}$, for this experiment. **3**

(iii) Name the pieces of laboratory equipment that are essential for carrying out this experiment. **2**

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4. (a) (continued)

(iv) Suggest a reason why the enthalpy of combustion determined experimentally is lower than the value given in the data booklet. **1**

(b) Alcohols can undergo oxidation reactions.

(i) Oxidation reactions involve a change in the oxygen to hydrogen ratio.

Determine the oxygen to hydrogen ratio for the alcohol ethane-1,2-diol. **1**

(ii) A primary alcohol, **X**, with the formula C_4H_9OH can undergo oxidation to compound **Y**.

(A) Suggest a suitable oxidising agent for this reaction. **1**

(B) Compound **Y** can be oxidised to give product **Z**, which turns universal indicator red.

Draw a structural formula for product **Z**. **1**

(C) Alcohol **X**, C_4H_9OH, has an isomer that is a secondary alcohol.

Name the product that would be formed by oxidation of this isomer. **1**

4. (continued)

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(c) The concentration of a solution of ethanoic acid can be determined using sodium hydroxide solution.

(i) A solution of ethanoic acid was prepared using a piece of glassware that allows the volume to be made up to exactly 250 cm^3.

Name this piece of glassware. **1**

(ii) A titration was carried out to calculate the accurate concentration of the ethanoic acid solution.

(A) A burette was rinsed with deionised water and then filled with sodium hydroxide solution.

Suggest an improvement that could be made to this step in the titration procedure. **1**

(B) Four 25.0 cm^3 samples of the ethanoic acid solution were titrated with 0.105 mol l^{-1} sodium hydroxide solution.

The results are shown in the table.

	Titration			
	1	**2**	**3**	**4**
Initial reading (cm^3)	0.2	21.0	0.4	20.4
Final reading (cm^3)	21.0	41.5	20.4	40.7
Volume used (cm^3)	20.8	20.5	20.0	20.3

Use these results to calculate the average volume used in cm^3. **1**

4. (c) (ii) (continued)

(C) In another experiment, 25.0 cm^3 samples of ethanoic acid were titrated with 0.105 mol l^{-1} sodium hydroxide solution. The average volume of sodium hydroxide solution used was 19.8 cm^3.

One mole of sodium hydroxide reacts with one mole of ethanoic acid.

Calculate the concentration, in mol l^{-1}, of the ethanoic acid. **3**

(iii) An impure sample of ethanoic acid, CH_3COOH, contained traces of potassium ethanoate.

(A) Write the ionic formula for potassium ethanoate. **1**

(B) A solution of the impure sample was prepared.

The concentration of ethanoic acid ($GFM = 60$ g) was found to be 0.45 mol l^{-1}.

Calculate the mass, in g, of ethanoic acid in 200 cm^3 of this solution. **1**