



Oxford Cambridge and RSA

Monday 20 May 2019 – Morning

AS Level Chemistry B (Salters)

H033/01 Foundations of chemistry

Time allowed: 1 hour 30 minutes

You must have:

- the Data Sheet for Chemistry B (Salters)
(sent with general stationery)

You may use:

- a scientific or graphical calculator



Please write clearly in black ink. **Do not write in the barcodes.**

Centre number

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Candidate number

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First name(s)

Last name

StemUp Model Solution

INSTRUCTIONS

- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

INFORMATION

- The total mark for this paper is **70**.
- The marks for each question are shown in brackets [].
- This document consists of **24** pages.

2
SECTION A

You should spend a maximum of 25 minutes on this section.

Answer **all** the questions.

Write your answer to each question in the box provided.

1 What is the outer subshell electron configuration of an element in Group 16 of the Periodic Table?

- A** p^4
- B** p^5
- C** p^6
- D** p^{16}

Your answer

A

[1]

2 Geiger and Marsden fired α -particles at a gold foil. What happened in their experiment?

- A** The α -particles were scattered randomly.
- B** Most α -particles passed through undeflected.
- C** Many α -particles bounced back.
- D** No α -particles were deflected.

Your answer

B

[1]

3 Which molecule has no lone pairs?

- A** BeCl_2
- B** CF_4
- C** NH_3
- D** BH_3

Your answer

D

[1]

4 What is the volume (in cm^3) of 4.4 g of CO_2 at RTP?

- A 105.6
- B 2.4×10^3
- C 2.4×10^4
- D 105 600

Your answer

B

[1]

5 Which reaction will give $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$ as a product?

- A Reduction of $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$
- B Treatment of $\text{CH}_2=\text{CHCH}_2\text{CH}_2\text{CH}_3$ with conc sulfuric acid followed by water
- C Heating $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}=\text{CH}_2$ with steam and phosphoric acid under pressure
- D Treatment of $\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}_3$ with conc sulfuric acid followed by water

Your answer

D

[1]

6 Which statement about the reaction $\text{RCl} + \text{NH}_3 \rightarrow \text{RNH}_2 + \text{HCl}$ is correct?

- A An amine is formed.
- B RCl is acting as an acid.
- C The reaction is electrophilic substitution.
- D An amide is formed.

Your answer

A

[1]

7 The mass spectrum of ethanoic acid has a peak at m/z 45. Which species could cause this?

- A CH_3COOH^+
- B COOH^+
- C $^{13}\text{CH}_3\text{COOH}^+$
- D CH_3^+

Your answer

B

[1]

8 What is formed at the cathode when aqueous aluminium sulfate is electrolysed?

- A Hydrogen
- B Oxygen
- C Aluminium
- D Sulfur dioxide

Your answer

A

[1]

9 Which term correctly describes cyclohexane?

- A Arene
- B Alkene
- C Aliphatic
- D Unsaturated

Your answer

C

[1]

10 Urea has formula $\text{CO}(\text{NH}_2)_2$.

What is the percentage of nitrogen by mass in urea?

- A 23%
- B 25%
- C 41%
- D 47%

Your answer

D

[1]

11 What is a property of solid iodine?

- A It is very soluble in water.
- B It is purple in colour.
- C It dissolves in organic solvents.
- D It melts when heated at room pressure.

Your answer

C

[1]

12 Silver nitrate solution is added to solutions of sodium halides.

Which row is correct?

	Halide	Precipitate formed with silver nitrate
A	chloride	white, insoluble in ammonia
B	iodide	cream, insoluble in ammonia
C	chloride	cream, soluble in ammonia
D	iodide	yellow, insoluble in ammonia

Your answer

D

[1]

13 What is the action (if any) of concentrated sulfuric acid on HBr?

- A No reaction
- B Forms SO_2
- C Forms H_2S
- D Forms sulfur

Your answer

B

[1]

14 Which molecule forms permanent dipole – permanent dipole bonds as its strongest intermolecular bond?

- A CH_3CHO
- B CH_3COOH
- C CCl_4
- D CO_2

Your answer

A

[1]

15 A student says that bio-ethanol is carbon neutral.

Which option provides evidence that disagrees with the student's statement about bio-ethanol?

- A It gives off carbon dioxide when it burns.
- B It is made from crops that absorb carbon dioxide.
- C Energy from conventional power-stations is used to make it.
- D Valuable land is used up growing the crops used to make bio-ethanol.

Your answer

C

[1]

16 Which substance **cannot** be made in a single step from C_2H_4 ?

A C_2H_5OH

B C_2H_5Br

C C_2H_6

D $C_2H_5NH_2$

Your answer

D

[1]

17 Which substance will **not** give 3-methylpentane when reduced with hydrogen?

A 2-ethylbut-1-ene

B 3-methylpent-2-ene

C 2-methylpent-1-ene

D 3-methylpent-1-ene

Your answer

C

[1]

18 What is **not** a reaction of 2-methylpropan-2-ol?

A Reaction with an acid anhydride to form an ester

B Oxidation to a ketone

C Dehydration to an alkene

D Reaction with HCl to form a haloalkane

Your answer

B

[1]

19 Which statement about instantaneous dipole – induced dipole bonds is correct?

- A They become weaker with increasing chain length of an organic compound.
- B They become stronger with increased branching in organic compounds.
- C They occur between molecules rather than atoms in molecules.
- D In any molecule they are always the weakest intermolecular bond.

Your answer

C

[1]

20 Which of the following is a redox reaction?

- A $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$
- B $2\text{CrO}_4^{2-} + 2\text{H}^+ \rightarrow \text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O}$
- C $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O}$
- D $\text{MgCO}_3 \rightarrow \text{MgO} + \text{CO}_2$

Your answer

A

[1]

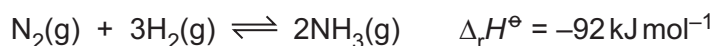
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SECTION B

Answer **all** the questions.

- 21** Ammonia is an important chemical used to make fertilisers. It is made in industry by the following equilibrium reaction.



Equation 1.1

- (a) Write down the value of $\Delta_f H^\ominus$ for $\text{NH}_3(\text{g})$.

Include the unit in your answer.

..-46 kJ mol⁻¹..... [1]

- (b) State what is happening to the forward and reverse reactions once equilibrium has been reached.

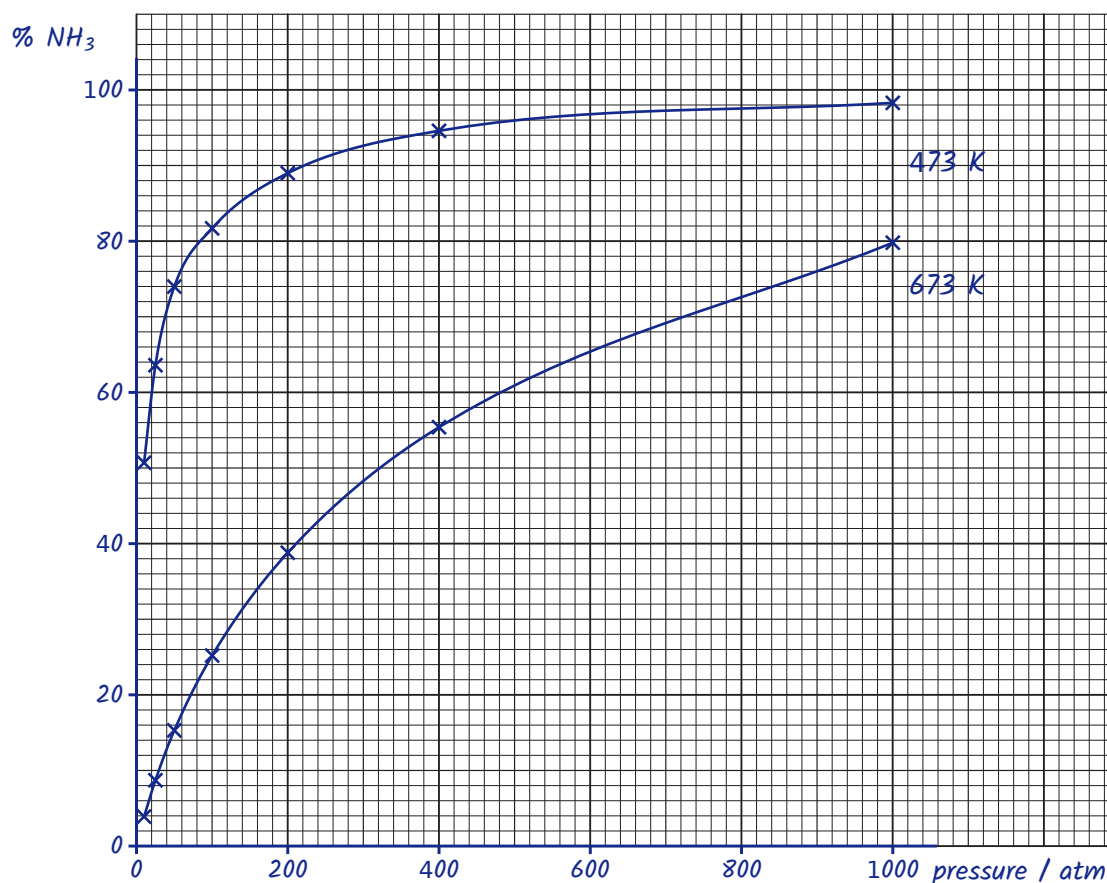
*..The forward and reverse reactions are both still happening, and their rates.....
are equal..... [1]*

- (c) The data in the **Table 21.1** shows the equilibrium percentages of ammonia formed under different conditions of temperature and pressure in the presence of an iron catalyst.

	Temperature/K	
	473	673
Pressure/atm	Equilibrium percentages of ammonia	
10	50.7	3.9
25	63.6	8.7
50	74.0	15.3
100	81.7	25.2
200	89.0	38.8
400	94.6	55.4
1000	98.3	79.8

Table 21.1

- (i) On the graph paper below plot the results in **Table 21.1** and draw lines of best fit.



[3]

- (ii) How would the plot for 673 K be different if the iron catalyst had **not** been used?

Explain your answer.

There would be no difference; the line would be the same.

A catalyst does not affect the position of equilibrium (the yield); it only speeds up how quickly equilibrium is reached.

[2]

- (iii) Explain why the yield is greater at higher pressures.

There are more moles of gas on the left (4 molecules) than on the right (2 molecules), so a higher pressure shifts the equilibrium position to the right.

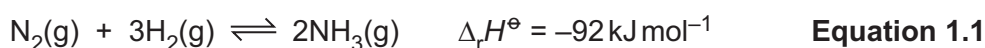
[1]

- (iv) A student says that an industrial firm carrying out the reaction at 473 K would not use a pressure above 400 atmospheres.

Discuss the student's statement, giving reasons.

Correct: at 400 atm the yield is already 94.6%, so it cannot increase much more (only to 98.3% at 1000 atm). Higher pressures are also expensive (more energy for compressors) and unsafe.

[2]



- (v) Ammonia is not often made at temperatures below 473 K. This is because the equilibrium is established too slowly at lower temperatures.

Explain why the rate of a reaction increases with temperature.

At a higher temperature the molecules move faster and have more energy, so more frequent collisions have energy greater than or equal to the activation enthalpy, E_a (more successful collisions).

[2]

- (d) The equilibrium shown in **equation 1.1** is set up.

The data below shows the composition of an equilibrium mixture at 473 K.

Equilibrium component	Equilibrium concentration/mol dm ⁻³
hydrogen	0.128
nitrogen	0.0403
ammonia	0.00271

Calculate the value of K_c for the reaction in **equation 1.1** at 473 K.

$$K_c = [\text{NH}_3]^2 / ([\text{N}_2][\text{H}_2]^3)$$

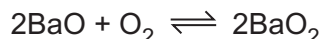
$$K_c = 0.00271^2 \div (0.0403 \times 0.128^3)$$

$$K_c = 7.344 \times 10^{-6} \div 8.452 \times 10^{-5}$$

$$K_c = 0.0869$$

value of K_c = *0.0869* [2]

- 22 Barium oxide, BaO, was once used to make oxygen gas. When heated above 500 °C, it combines with oxygen from the air to form barium peroxide, BaO₂. Above 700 °C, BaO₂ decomposes to give barium oxide and pure oxygen.



The removal of CO₂ from the air enabled the cycle to be carried out many times.

- (a) Suggest why the removal of carbon dioxide was necessary.

Carbon dioxide would react with the barium oxide to form barium carbonate, BaCO₃, so the BaO would be used up. [1]

- (b) Barium oxide is made by heating barium carbonate.



- (i) How does the thermal stability of barium carbonate compare with the thermal stability of calcium carbonate?

Explain your answer.

Barium carbonate has a higher thermal stability than calcium carbonate (it needs a higher temperature to decompose). Both ions have the same 2+ charge, but the Ba²⁺ ion is larger than the Ca²⁺ ion, so Ba²⁺ has a smaller charge density. So Ba²⁺ polarises (distorts) the electron cloud of the carbonate ion less, so the C-O bonds in the carbonate ion are weakened less and BaCO₃ is harder to decompose into BaO and CO₂. [4]

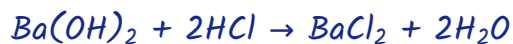
- (ii) Why is it valid to compare barium carbonate with calcium carbonate?

Barium and calcium are both in Group 2, so both form ions with the same 2+ charge. [1]

(c) Barium oxide dissolves in water to form barium hydroxide, Ba(OH)_2 .

In a titration 25.0 cm^3 of a solution of Ba(OH)_2 reacts with 23.6 cm^3 of 0.120 mol dm^{-3} HCl .

(i) Write the equation for the reaction in the titration.



[1]

(ii) Calculate the concentration of Ba(OH)_2 in mol dm^{-3} .

$$n(\text{HCl}) = 0.120 \times 23.6 \div 1000 = 2.832 \times 10^{-3} \text{ mol}$$

$$n(\text{Ba(OH)}_2) = 2.832 \times 10^{-3} \div 2 = 1.416 \times 10^{-3} \text{ mol}$$

$$\text{concentration} = 1.416 \times 10^{-3} \times 1000 \div 25.0$$

$$= 0.0566 \text{ mol dm}^{-3}$$

$$\text{concentration} = \dots\dots\dots 0.0566 \dots\dots\dots \text{ mol dm}^{-3} \text{ [2]}$$

(iii) Calculate the concentration of Ba(OH)_2 in g dm^{-3} .

$$M_r \text{ Ba(OH)}_2 = 137.3 + 2 \times (16.0 + 1.0) = 171.3$$

$$0.0566 \times 171.3 = 9.70 \text{ g dm}^{-3}$$

$$\text{concentration} = \dots\dots\dots 9.70 \dots\dots\dots \text{ g dm}^{-3} \text{ [1]}$$

- 23 When ammonium nitrate, NH_4NO_3 , dissolves in water, the process is endothermic. This process is used in 'ice packs' that are used for sports injuries.

(a) A group of students dissolve 8.0 g of ammonium nitrate in 200cm^3 of water. The temperature falls by 3.0°C .

(i) Calculate the enthalpy change on dissolving 1 mol of ammonium nitrate in water.

Give your answer in kJ mol^{-1} and to an **appropriate** number of significant figures.

$$\text{energy absorbed} = mc\Delta T = 200 \times 4.18 \times 3.0 = 2508 \text{ J} = 2.508 \text{ kJ}$$

$$M_r \text{ NH}_4\text{NO}_3 = 80.0, \text{ so } n = 8.0 \div 80.0 = 0.10 \text{ mol}$$

$$\Delta H = +2.508 \div 0.10 = +25.08 \text{ kJ mol}^{-1}$$

$$= +25 \text{ kJ mol}^{-1} \text{ (2 s.f., as the data are to 2 s.f.)}$$

$$\Delta H = \dots\dots\dots +25 \dots\dots\dots \text{ kJ mol}^{-1} \text{ [3]}$$

(ii) The students want to get a larger temperature change. Some suggest using a greater mass of ammonium nitrate, others suggest using more water.

Evaluate the students' suggestions.

A greater mass of ammonium nitrate (same volume of water) is
correct: more moles dissolve, so more energy is absorbed from the same
mass of water and ΔT is larger. More water is incorrect: the same
energy comes from a larger mass of water, so ΔT would be smaller. [2]

- (b) Another group of students investigates the exothermic reaction between zinc and copper sulfate solution.



- (i) The students are provided with powdered zinc metal and solid $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ($M_r = 250$).

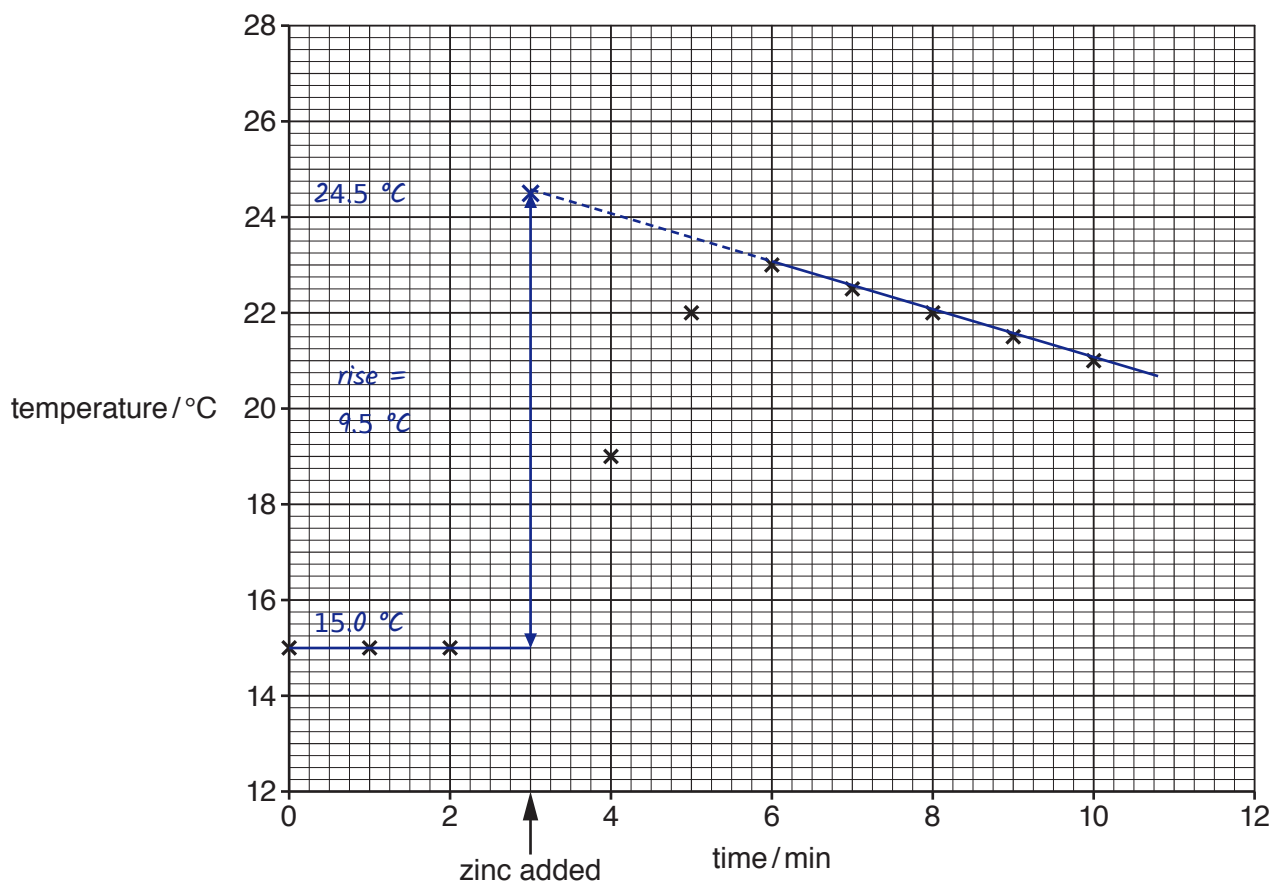
They measure the temperature rise when 100 cm^3 (an excess) of 0.2 mol dm^{-3} copper sulfate is used.

Design a suitable method to investigate this exothermic reaction.

..Weigh out 5.0 g of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ($0.020 \text{ mol} \times 250 = 5.0 \text{ g}$) and.....
 ..dissolve it in distilled water, making it up to 100 cm^3 in a volumetric.....
 ..flask to give a 0.2 mol dm^{-3} solution.....
 ..Put the 100 cm^3 of solution into an insulated polystyrene cup (with a.....
 ..lid) and measure its starting temperature with a thermometer.....
 ..Weigh out about 1.0 g of zinc powder (less than 1.3 g, which is 0.020.....
 ..mol, so that the copper sulfate is in excess).....
 ..Add the zinc powder, stir and record the highest temperature reached.....
 ..Temperature rise = highest temperature – starting temperature.....

[5]

- (ii) The students repeat the experiment, measuring the temperature at different times. They plot the graph shown.



Use the graph to make an accurate measure of the temperature rise.
Show your working on the graph.

temperature rise = ...9.5..... °C [2]

- 24 Willow bark contains salicin. Salicylic acid is obtained from willow bark by first hydrolysing the salicin to salicyl alcohol, which is a solid at room temperature.

The structures of salicylic acid and salicyl alcohol are shown in Fig. 24.1.

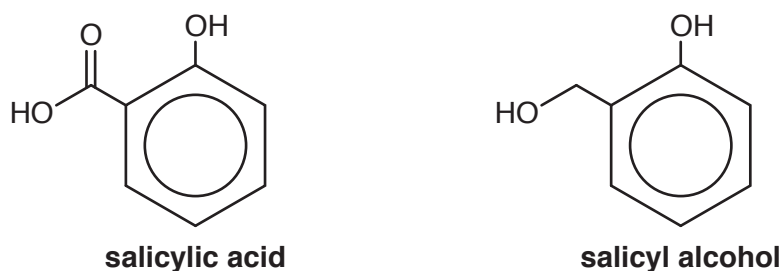


Fig. 24.1

- (a) Name the **two** types of hydroxyl group that are present in salicyl alcohol.
- 1 ...*phenol (phenolic OH)*.....
- 2 ...*primary alcohol*..... [2]
- (b) Suggest laboratory reagents and conditions for converting salicyl alcohol to salicylic acid.
- Reagents ...*acidified potassium dichromate(VI)*.....
- ...*(K₂Cr₂O₇ with dilute H₂SO₄), in excess*.....
- Conditions ...*heat under reflux*..... [2]
- (c) Some students have an impure sample of salicyl alcohol. They wish to purify it by recrystallisation from water.
- (i) Give the **first** step in the recrystallisation process.
- ...*Dissolve the impure solid in the minimum volume of hot water*.....
- [2]
- (ii) How would the students show that their recrystallised product was purer than the impure sample?
- ...*Measure the melting point: the recrystallised product has a higher*.....
- ...*melting point with a smaller (sharper) range, closer to the data book*.....
- ...*value*..... [1]

- (d) The students make some predictions about salicyl alcohol.

They predict that salicyl alcohol will fizz with sodium carbonate solution.

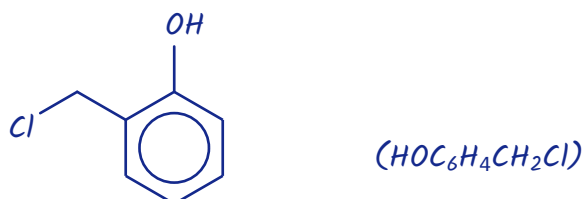
They also predict that salicyl alcohol will dehydrate when heated over Al_2O_3 to give a substance that will decolourise bromine water.

Comment on their predictions, giving chemical explanations.

Both predictions are wrong. It will not fizz with sodium carbonate: phenols (and alcohols) are not acidic enough to react with carbonates, and there is no COOH group, so no CO_2 forms. It will not dehydrate to an alkene: there is no H on the carbon adjacent to the carbon with the OH group (that carbon is in the benzene ring), so no C=C double bond forms and bromine water is not decolourised. [3]

- (e) (i) When salicyl alcohol reacts with concentrated hydrochloric acid, only one –OH group reacts.

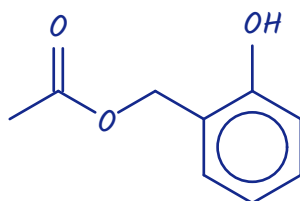
Write the formula of the product formed.



[1]

- (ii) Salicyl alcohol reacts with ethanoic acid in the presence of concentrated sulfuric acid.

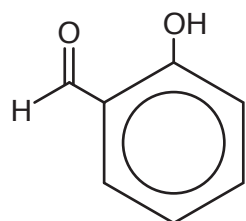
Draw the **skeletal** formula of the product formed.



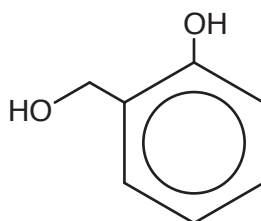
[1]

- (f) The boiling point of salicylaldehyde is 197°C and the boiling point of salicyl alcohol is 267°C .

The structures of salicylaldehyde and salicyl alcohol are shown in **Fig. 24.2**.



salicylaldehyde (197°C)



salicyl alcohol (267°C)

Fig. 24.2

Explain the difference in boiling points between salicylaldehyde and salicyl alcohol in terms of intermolecular bonds.

Both form hydrogen bonds between molecules, because both have an OH group (H bonded to O). Salicyl alcohol has two OH groups, so it forms more hydrogen bonds per molecule; its intermolecular bonds are stronger, so more energy is needed to overcome them. [2]

[illegible]

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