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 ☐☐☐☐☐ Candidate number ☐☐☐☐

First name(s) ______________________________

Last name ______________________________

### 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.

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## 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 ☐ **[1]**

**2** Geiger and Marsden fired $\alpha$-particles at a gold foil. What happened in their experiment?

**A** The $\alpha$-particles were scattered randomly.

**B** Most $\alpha$-particles passed through undeflected.

**C** Many $\alpha$-particles bounced back.

**D** No $\alpha$-particles were deflected.

Your answer ☐ **[1]**

**3** Which molecule has no lone pairs?

**A** $BeCl_2$

**B** $CF_4$

**C** $NH_3$

**D** $BH_3$

Your answer ☐ **[1]**

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

**A** 105.6

**B** $2.4 \times 10^3$

**C** $2.4 \times 10^4$

**D** 105 600

Your answer ☐ **[1]**

**5** Which reaction will give $CH_3CH_2CH(OH)CH_2CH_3$ as a product?

**A** Reduction of $CH_3CH_2CH_2CH_2CHO$

**B** Treatment of $CH_2=CHCH_2CH_2CH_3$ with conc sulfuric acid followed by water

**C** Heating $CH_3CH_2CH_2CH=CH_2$ with steam and phosphoric acid under pressure

**D** Treatment of $CH_3CH=CHCH_2CH_3$ with conc sulfuric acid followed by water

Your answer ☐ **[1]**

**6** Which statement about the reaction $RCl + NH_3 \rightarrow RNH_2 + HCl$ 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 ☐ **[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** $^{13}CH_3COOH^+$

**D** $CH_3^+$

Your answer ☐ **[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 ☐ **[1]**

**9** Which term correctly describes cyclohexane?

**A** Arene

**B** Alkene

**C** Aliphatic

**D** Unsaturated

Your answer ☐ **[1]**

**10** Urea has formula $CO(NH_2)_2$.

What is the percentage of nitrogen by mass in urea?

**A** 23%

**B** 25%

**C** 41%

**D** 47%

Your answer ☐ **[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 ☐ **[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 ☐ **[1]**

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**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 ☐ **[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 ☐ **[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 ☐ **[1]**

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**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 ☐ **[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 ☐ **[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 ☐ **[1]**

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**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 ☐ **[1]**

**20** Which of the following is a redox reaction?

**A** $2Na + 2H_2O \rightarrow 2NaOH + H_2$

**B** $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$

**C** $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O$

**D** $MgCO_3 \rightarrow MgO + CO_2$

Your answer ☐ **[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.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta_r H^{\ominus} = -92\,kJ\,mol^{-1}$ **Equation 1.1**

**(a)** Write down the value of $\Delta_f H^{\ominus}$ for $NH_3(g)$.

Include the unit in your answer.

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

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**(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**

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**(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.

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

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**(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.

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$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta_r H^\ominus = -92\,kJ\,mol^{-1}$ **Equation 1.1**

**(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.

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**(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.

value of $K_c$ = ........................................................... **[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, $BaO_2$. Above 700 °C, $BaO_2$ decomposes to give barium oxide and pure oxygen.

$$2BaO + O_2 \rightleftharpoons 2BaO_2$$

The removal of $CO_2$ from the air enabled the cycle to be carried out many times.

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

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

$$BaCO_3 \rightarrow BaO + CO_2$$

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

Explain your answer.

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

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**(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 $dm^{-3}$ HC*l*.

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

**[1]**

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

concentration = .......................................... mol $dm^{-3}$ **[2]**

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

concentration = ............................................. g $dm^{-3}$ **[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 200 cm$^3$ 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.

$\Delta H$ = ........................................... kJ mol$^{-1}$ **[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.

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

$Zn(s) + CuSO_4(aq, 0.2\,mol\,dm^{-3}) \longrightarrow Cu(s) + ZnSO_4(aq)$

**(i)** The students are provided with powdered zinc metal and solid $CuSO_4{\bullet}5H_2O$ ($M_r$ = 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.

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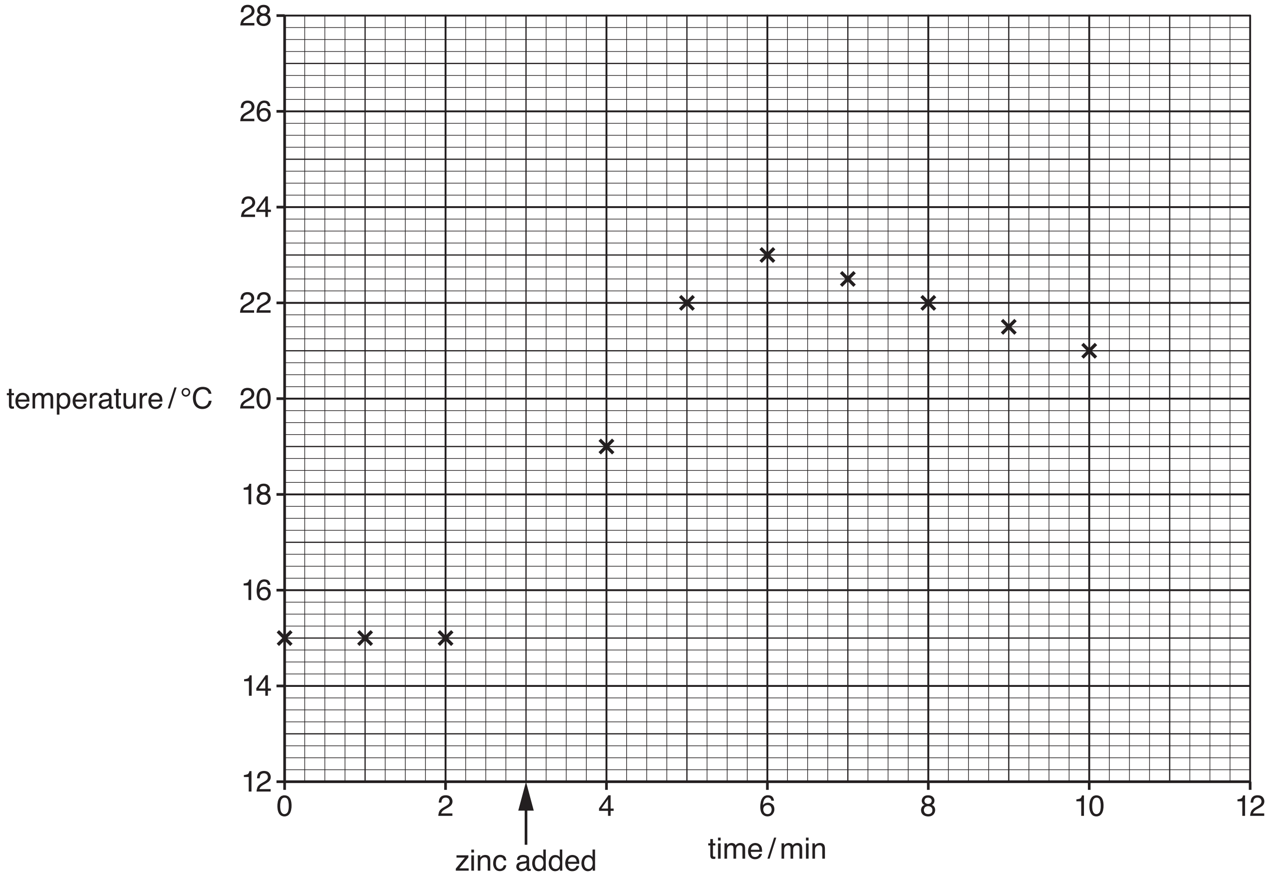
**(ii)** The students repeat the experiment, measuring the temperature at different times. They plot the graph shown.

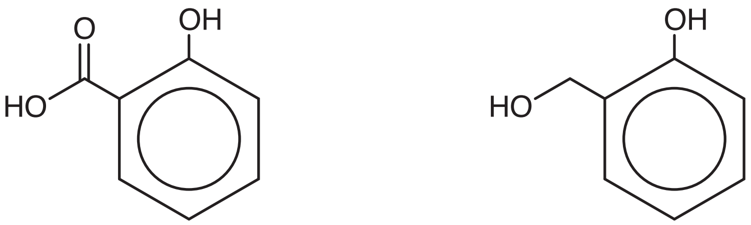


Use the graph to make an accurate measure of the temperature rise.
Show your working on the graph.

temperature rise = .................................................... °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**.



**salicylic acid** **salicyl alcohol**

**Fig. 24.1**

**(a)** Name the **two** types of hydroxyl group that are present in salicyl alcohol.

1 ..............................................................................................................................

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

**(b)** Suggest laboratory reagents and conditions for converting salicyl alcohol to salicylic acid.

Reagents ..............................................................................................................................

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Conditions .............................................................................................................................. **[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.

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**(ii)** How would the students show that their recrystallised product was purer than the impure sample?

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**(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.

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

Write the formula of the product formed.

**[1]**

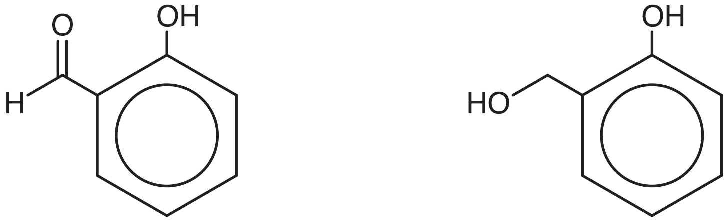
**(ii)** Salicyl alcohol reacts with ethanoic acid in the presence of concentrated sulfuric acid.

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.

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**END OF QUESTION PAPER**

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## ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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