



Oxford Cambridge and RSA

# A Level Chemistry B (Salters)

H433/02 Scientific literacy in chemistry

**Tuesday 12 June 2018 – Afternoon**

**Time allowed: 2 hours 15 minutes**



**You must have:**

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

**You may use:**

- a scientific or graphical calculator



First name

Last name

Centre  
number

Candidate  
number

## INSTRUCTIONS

- The Insert will be found inside this document.
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- 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.
- Do **not** write in the barcodes.

## INFORMATION

- The total mark for this paper is **100**.
- The marks for each question are shown in brackets [ ].
- Quality of extended responses will be assessed in questions marked with an asterisk (\*).
- This document consists of **20** pages.

Answer **all** the questions.

- 1 'Morton's salt'™ contains a mixture of sodium chloride with magnesium carbonate. It is advertised using the slogan 'When it rains it pours' indicating that the table salt is free-flowing in humid weather.

Magnesium carbonate is hygroscopic (absorbs water) and forms hydrated salts, eg  $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$ , but does not dissolve. This stops the sodium chloride absorbing water.

- (a) (i) Some data for the dissolving of  $\text{NaCl}$  is given below.

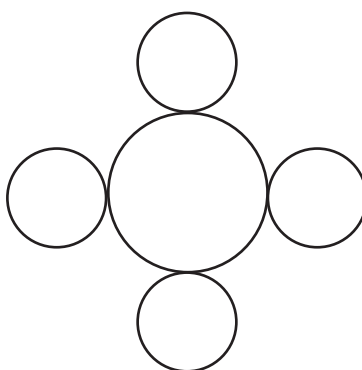
Enthalpy change	Value / $\text{kJ mol}^{-1}$
$\Delta_{\text{LE}}H \text{ NaCl}$	-780
$\Delta_{\text{hyd}}H \text{ Na}^+$	-402
$\Delta_{\text{hyd}}H \text{ Cl}^-$	-374

Calculate a value for the enthalpy change of solution of  $\text{NaCl}$ .

enthalpy change of solution of  $\text{NaCl} = \dots\dots\dots$  [1]

- (ii) The diagram below shows the pattern of ions in **one face** of a  $\text{NaCl}$  lattice. Extend the diagram to show the repeating pattern by adding **three** more suitable ions.

Label one  $\text{Na}^+$  ion and one  $\text{Cl}^-$  on the diagram.



[2]

- (b) Some students heat a sample of  $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$  to try to make  $\text{MgCO}_3$ .

Calculate the percentage loss in mass they will obtain if they succeed.

percentage loss in mass = ..... % [2]

- (c) The students continue to heat the  $\text{MgCO}_3$  formed and realise that the compound is decomposing, giving off  $\text{CO}_2$  gas.

The students want to obtain  $200 \text{ cm}^3$   $\text{CO}_2$  at 290 K and 99 kPa.

What mass of  $\text{MgCO}_3$  should they heat?

mass of  $\text{MgCO}_3$  = ..... g [3]

- (d) Magnesium has a higher first ionisation enthalpy than calcium.

- (i) Write an equation for the reaction for the first ionisation enthalpy of magnesium.

Include state symbols.

[1]

- (ii) Explain why magnesium has a higher first ionisation enthalpy than calcium.

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

- (e) Some students are given a mixture of magnesium carbonate with another Group 2 carbonate. They dissolve the mixture in an acid. They test the solution of salts formed as shown in the table below.

Test	Result
Flame test	Green flame
Add dilute nitric acid followed by silver nitrate solution	White precipitate

- (i) Name the acid that the students used to dissolve the mixture of carbonates.

..... [1]

- (ii) Name the other Group 2 carbonate that was mixed with the magnesium carbonate.

..... [1]

- 2 Propene gas,  $C_3H_6$ , is obtained industrially from a variety of sources. Propene is mainly used as a starting material for making polymers.

(a) The mass spectrum of propene has several peaks including those at  $m/z$  27 and 43.

(i) Give the species responsible for these peaks

27 .....

43 .....

[2]

(ii) Propene has an isomer, cyclopropane.

Explain why high-resolution mass spectrometry would **not** distinguish between propene and cyclopropane.

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

(iii) Suggest, with reasons, **two** spectroscopic methods (apart from mass spectroscopy) that would distinguish between cyclopropane and propene.

Method 1 .....

Reason: .....

.....  
 .....

Method 2 .....

Reason: .....

.....  
 .....

[4]

(b) (i) How many  $\sigma$  and  $\pi$  bonds are there in a propene molecule?

Number of  $\sigma$  bonds ..... Number of  $\pi$  bonds ..... [1]

(ii) Propene has a H–C–H bond where the C atom forms a double bond.

What is the bond angle of this H–C–H bond?

..... [1]

(c) Propene,  $C_3H_6$ , can be made by cracking longer-chain hydrocarbons.

(i) Write the equation for the cracking of nonane to give two molecules of propene and one other molecule.

[1]

(ii) What mass of propene (in kg) would be obtained from 15 kg of nonane in the reaction in (i) if the percentage yield was 85%?

mass of propene = ..... kg [2]

(d) Most of the propene that is manufactured is used to make the polymer poly(propene).

Draw the **full** structural formula of the repeating unit of poly(propene).

[1]

(e) Cyclohexene is another industrially important alkene.

(i) Explain how the enthalpy change of hydrogenation of cyclohexene is used to give evidence for the bonding in the benzene molecule.

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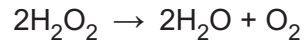
.....

.....

..... [3]



- 3 Why does human hair turn grey? Studies have shown that this is caused by lower levels of the enzyme catalase in hair follicles. Catalase catalyses the breakdown of hydrogen peroxide as shown in **equation 3.1**.



**Equation 3.1**

When levels of hydrogen peroxide increase, the melanin (dye) in the hair is bleached.

- (a) Catalase has an active site.

Explain how this results in faster decomposition of hydrogen peroxide.

.....

.....

.....

..... [3]

- (b) Suggest the **type** of reaction by which hydrogen peroxide bleaches melanin.

..... [1]





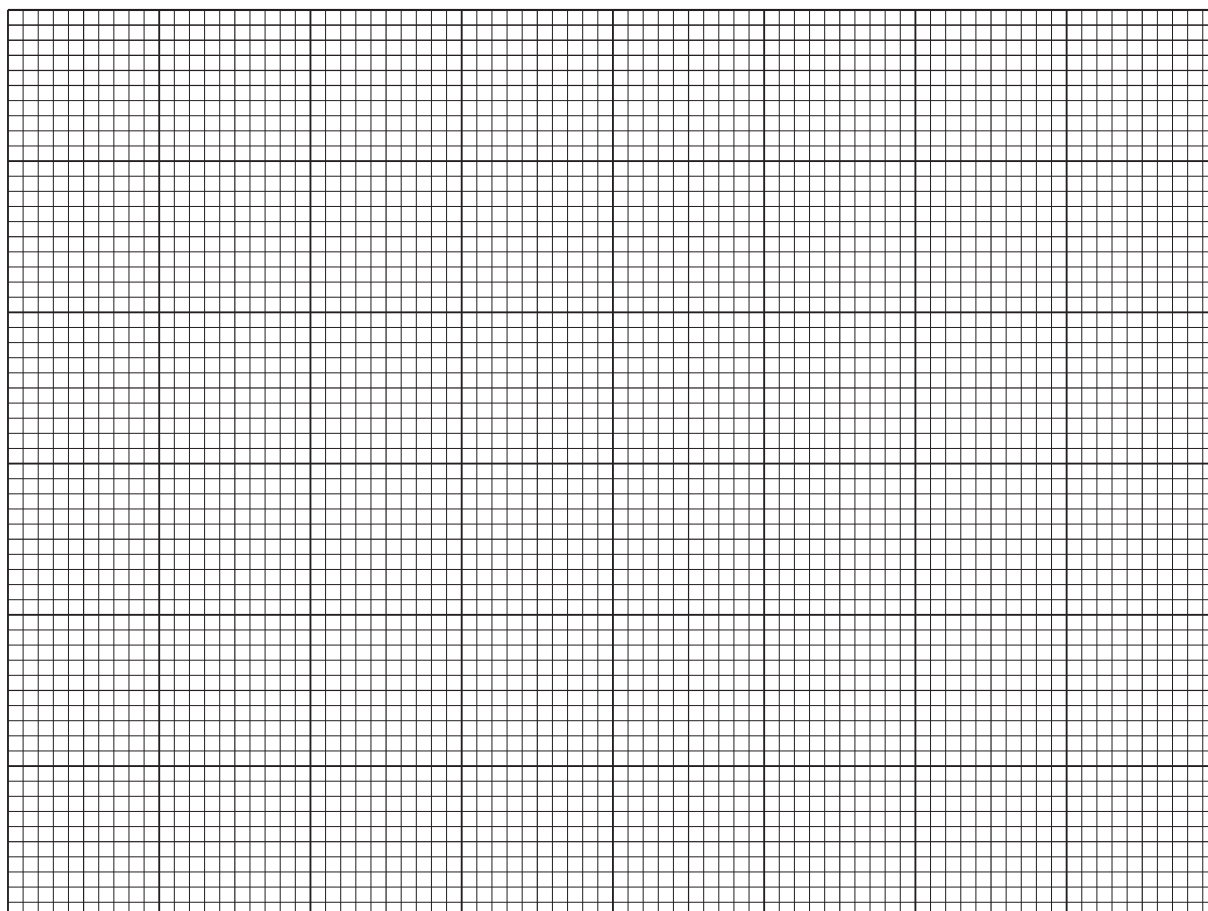
(d) The students record their results as shown in the box below.

Concentrations of hydrogen peroxide: 0.05 – 0.35 in 0.05 intervals.  
Units of concentration  $\text{mol dm}^{-3}$   
Corresponding relative rates of reaction: 1.0; 2.1; 3.0; 3.8; 4.0; 4.1; 4.1  
Temperature: 20 °C

(i) Arrange the results in a more appropriate format.

[2]

(ii) Use the grid below to plot a graph of the results and draw a line of best fit.



[4]

(e) A student says that the graph shows that the decomposition of hydrogen peroxide is first order with respect to both the hydrogen peroxide concentration and the catalase concentration.

- (i) Write the rate equation that would follow from the student's statement.  
Give the units of the rate constant.

Rate equation:

Units of rate constant ..... [2]

- (ii) Explain why the student is incorrect and give the correct information.

.....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

(f) Hydrogen peroxide concentration is often measured as 'volume strength'.  
1 cm<sup>3</sup> of '1 volume' hydrogen peroxide produces 1 cm<sup>3</sup> of oxygen at RTP.

Calculate the 'volume strength' of the 0.35 mol dm<sup>-3</sup> hydrogen peroxide used by the students.



Give your answer to an **appropriate** number of significant figures.

'volume strength' = ..... volume [3]

(g) The students have 20.0 cm<sup>3</sup> 0.35 mol dm<sup>-3</sup> H<sub>2</sub>O<sub>2</sub> and wish to make a 0.05 mol dm<sup>-3</sup> solution.

How much water should they add?

volume of water to add = ..... cm<sup>3</sup> [2]

- 4 The pH of human blood needs to be held within strict limits for good health. The pH is controlled using buffer systems. One buffer system is based on the equilibrium in **equation 4.1**.



- (a) (i) Give the **systematic** name for  $\text{HCO}_3^-$ .  
 ..... [1]

- (ii)  $\text{HCO}_3^-$  can act as either an acid or a base.  
 Give the **formula** of the conjugate **base** of  $\text{HCO}_3^-$ .  
 ..... [1]

- (b) (i) Draw a 'dot-and-cross' diagram for  $\text{CO}_2$  and use it to name the shape of the molecule.

'Dot-and-cross' diagram:

Shape of molecule ..... [2]

- (ii) A  $\text{CO}_2$  molecule has no dipole.  
 A student says that this is because bonds between carbon and oxygen atoms are not polar.

Discuss the student's statement.

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

- (c) Another student says that  $\text{CO}_2$  will form only instantaneous dipole-induced dipole bonds with water molecules.

Explain why this is incorrect.

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

(d) For the equilibrium in **equation 4.1**:

$$K_a = \frac{[\text{HCO}_3^-][\text{H}^+]}{[\text{CO}_2(\text{aq})]} = 7.9 \times 10^{-7} \text{ mol dm}^{-3}$$

(i) A saturated solution of  $\text{CO}_2$  at 298K has a concentration of  $3.3 \times 10^{-2} \text{ mol dm}^{-3}$ .

Calculate the pH of this solution.

pH = ..... [2]

(ii) Calculate the concentration of a solution of  $\text{HCl}$  that has the same pH as the solution in (i).

concentration = .....  $\text{mol dm}^{-3}$  [1]

(e) (i) The pH of healthy human blood is 7.4.

Calculate the ratio of  $\frac{[\text{HCO}_3^-]}{[\text{CO}_2]}$  in healthy human blood.

$\frac{[\text{HCO}_3^-]}{[\text{CO}_2]} = \dots\dots\dots$  [2]

- (ii) A patient's blood has a pH below 7.4. A student says that  $\text{HCO}_3^-$  needs to be added to the patient's blood.

Say, with reasons, whether the student is correct.

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

- (f) Some students mix  $20\text{ cm}^3$  of  $5.0 \times 10^{-3}\text{ mol dm}^{-3}\text{ HCl}$  with  $20\text{ cm}^3$  of  $1.0 \times 10^{-2}\text{ mol dm}^{-3}\text{ NaOH}$ .

Calculate the pH of the resulting solution.

pH = ..... [3]

5 This question concerns the pre-release article *The Strange Story of Napoleon's Wallpaper* that is included as an insert with this paper.

(a) One reason arsenic is poisonous because it reacts with –SH groups in amino acids.

Suggest how the removal of –SH groups might interfere with the way these amino acids form proteins.

.....  
 ..... [1]

(b) Arsenate(V) can replace phosphate(V) in nucleic acids.

Draw the skeletal formula of a DNA nucleotide containing thymine and with As instead of P.

[2]

(c) Write an equation for the reaction of a solution of  $\text{As}^{3+}$  with hydrogen sulfide. Show state symbols.

[2]

(d) A Marsh test is carried out for arsenic in a sample of  $\text{As}_2\text{O}_3$ .

(i) Draw a labelled diagram of a suitable apparatus, showing the reactants and products.

[3]

(ii) Write equations for the formation and decomposition of arsine in the apparatus.

[2]

(e) The structure of Scheele's green can be represented as  $\text{Cu}^{2+}(\text{AsO}_2\text{OH})^{2-}$ .

(i) Suggest a 'dot-and-cross' diagram for the anion in Scheele's green.

[2]

(ii) State which part of Scheele's green is responsible for the green colour.

..... [1]

(f) State and explain the C–As–C bond angle in trimethylarsine.

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.....  
..... [4]

(g) Summarise the evidence that Napoleon was killed by his wallpaper.

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.....  
.....  
..... [3]

END OF QUESTION PAPER



**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).

A large area of lined paper for writing, consisting of 25 horizontal dotted lines. A solid vertical line runs down the left side of the page, creating a margin. The rest of the page is open for writing.





A large area of the page is reserved for writing, featuring a vertical solid line on the left side and horizontal dotted lines extending across the page.



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