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.

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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 hydroscopic (absorbs water) and forms hydrated salts, eg $MgCO_3 \bullet 3H_2O$, but does not dissolve. This stops the sodium chloride absorbing water.

(a) (i) Some data for the dissolving of NaC*l* is given below.

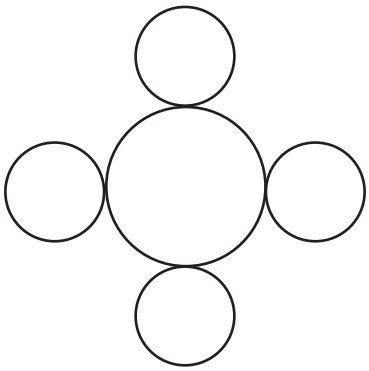
Enthalpy change	**Value / kJ mol^{-1}**
$\Delta_{LE}H$ NaC*l*	−780
$\Delta_{hyd}H$ Na^+	−402
$\Delta_{hyd}H$ Cl^-	−374

Calculate a value for the enthalpy change of solution of NaC*l*.

enthalpy change of solution of NaC*l* = ... **[1]**

(ii) The diagram below shows the pattern of ions in **one face** of a NaC*l* lattice.
Extend the diagram to show the repeating pattern by adding **three** more suitable ions.

Label one Na^+ ion and one Cl^- on the diagram.



[2]

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(b) Some students heat a sample of $MgCO_3 \cdot 3H_2O$ to try to make $MgCO_3$.

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

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

(c) The students continue to heat the $MgCO_3$ formed and realise that the compound is decomposing, giving off CO_2 gas.

The students want to obtain 200 cm^3 CO_2 at 290 K and 99 kPa.

What mass of $MgCO_3$ should they heat?

mass of $MgCO_3$ = ... 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.

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.....

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

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(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]**

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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.

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

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

Method 1 .....

Reason: .....

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Method 2 .....

Reason: .....

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[4]

(b) **(i)** How many σ and π bonds are there in a propene molecule?

Number of σ bonds ..... Number of π 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]**

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(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]**

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(ii)* Cyclohexene and benzene both react with bromine but in different ways.

Compare the two reactions and explain why they are different.

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..... **[6]**

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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**.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$ **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.

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

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

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

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(c)* Some students are given a solution of catalase and solutions of hydrogen peroxide of different concentrations. They study the rate of reaction in **equation 3.1**.

They determine the relative initial rates of reaction at the different hydrogen peroxide concentrations, using the volume of oxygen produced.

Suggest the procedure they follow, including how the students should process their results. You may include a diagram as part of your answer.

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..... **[6]**

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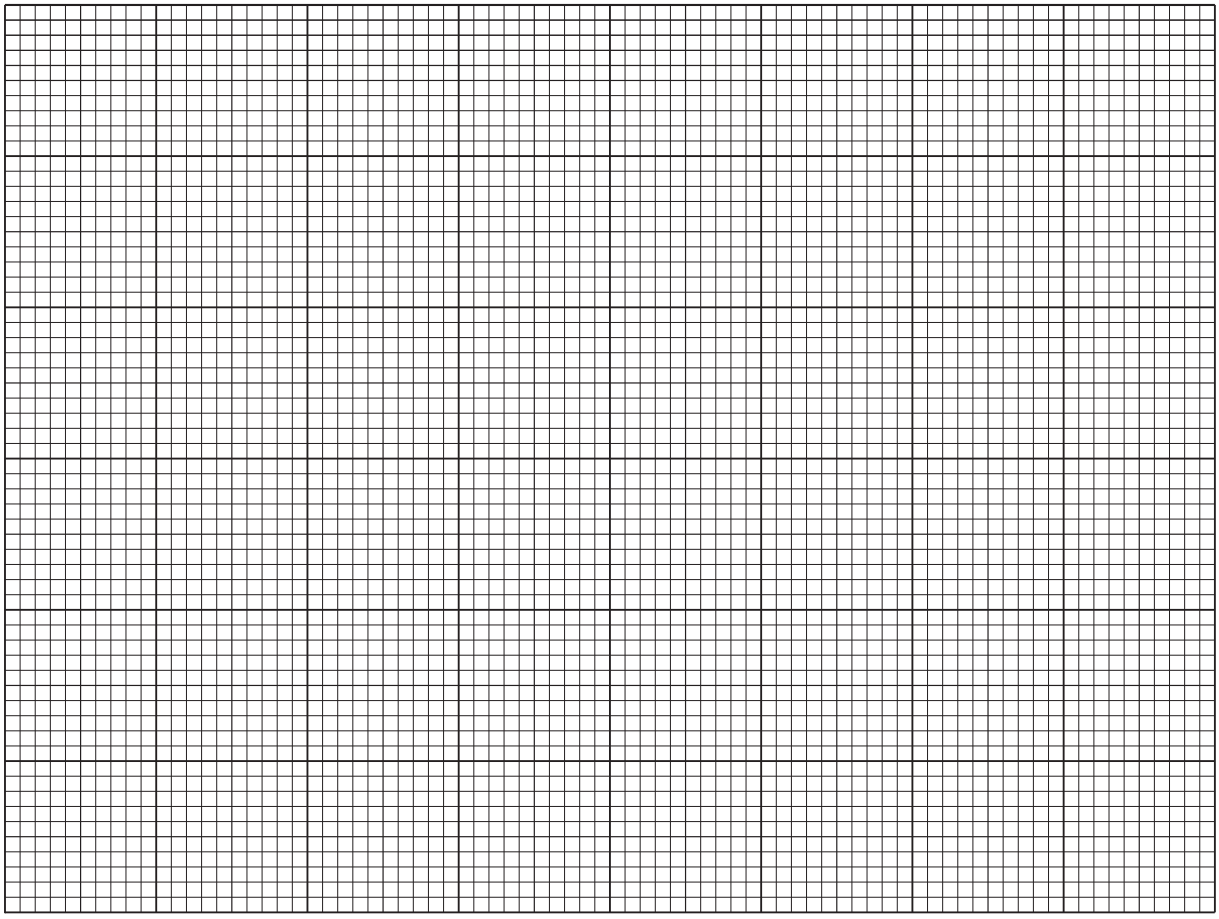
(d) The students record their results as shown in the box below.

Concentrations of hydrogen peroxide: 0.05 – 0.35 in 0.05 intervals. Units of concentration $mol\,dm^{-3}$ 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]

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(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.

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

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

Calculate the 'volume strength' of the 0.35 mol dm^{-3} hydrogen peroxide used by the students.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$ **Equation 3.1**

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

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

(g) The students have 20.0 cm^3 0.35 mol dm^{-3} H_2O_2 and wish to make a 0.05 mol dm^{-3} solution.

How much water should they add?

volume of water to add = ... cm^3 **[2]**

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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**.

$$CO_2 + H_2O \rightleftharpoons HCO_3^- + H^+$$ **Equation 4.1**

(a) **(i)** Give the **systematic** name for HCO_3^-.

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

(ii) HCO_3^- can act as either an acid or a base.

Give the **formula** of the conjugate **base** of HCO_3^-.

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

(b) **(i)** Draw a *'dot-and-cross'* diagram for CO_2 and use it to name the shape of the molecule.

'Dot-and-cross' diagram:

Shape of molecule ..... **[2]**

(ii) A 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.

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

(c) Another student says that CO_2 will form only instantaneous dipole-induced dipole bonds with water molecules.

Explain why this is incorrect.

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

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

$$K_a = \frac{[HCO_3^-]\,[H^+]}{[CO_2(aq)]} = 7.9 \times 10^{-7}\,mol\,dm^{-3}$$

(i) A saturated solution of CO_2 at 298 K has a concentration of $3.3 \times 10^{-2}\,mol\,dm^{-3}$.

Calculate the pH of this solution.

pH = ... **[2]**

(ii) Calculate the concentration of a solution of HC*l* that has the same pH as the solution in **(i)**.

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

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

Calculate the ratio of $\frac{[HCO_3^-]}{[CO_2]}$ in healthy human blood.

$\frac{[HCO_3^-]}{[CO_2]}$ = ... **[2]**

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(ii) A patient's blood has a pH below 7.4. A student says that HCO_3^- needs to be added to the patient's blood.

Say, with reasons, whether the student is correct.

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

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

Calculate the pH of the resulting solution.

pH = ... **[3]**

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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 As^{3+} with hydrogen sulfide.
Show state symbols.

[2]

(d) A Marsh test is carried out for arsenic in a sample of As_2O_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]

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(e) The structure of Scheele's green can be represented as $Cu^{2+}(AsO_2OH)^{2-}$.

(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

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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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