



Tuesday 13 October 2020 – Morning

AS Level Chemistry B (Salters)

H033/02 Chemistry in depth

Time allowed: 1 hour 30 minutes

You must have:

• the Data Sheet for Chemistry B

You can use:

- · a scientific or graphical calculator
- an HB pencil



Please write cle	arly in	black	ink.	Do no	ot writ	e in the barcodes.		
Centre number						Candidate number		
First name(s)								
Last name								

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer all the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION

- The total mark for this paper is 70.
- The marks for each question are shown in brackets [].
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has 20 pages.

ADVICE

· Read each question carefully before you start your answer.

2

Answer all the questions.

1 Natural rubber is a polymer of 2-methylbuta-1,3-diene.

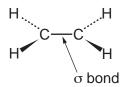
2-methylbuta-1,3-diene

(a) Draw the **skeletal** formula of 2-methylbuta-1,3-diene.

[1]

- **(b)** The carbon-carbon double bond consists of both a sigma(σ) and a pi(π) bond.
 - (i) The diagram of ethene below shows the position of the sigma(σ) bond between the carbon atoms.

On the diagram sketch the shape and position of the $pi(\pi)$ bond.



[1]

(ii) Explain the meaning of the wedge bond (—) in terms of the 3-D shape of ethene.

(c) 2-chlorobuta-1,3-diene, CH₂=CClCH=CH₂ is made in industry.

It polymerises, as shown in equation 1.1.

2-chlorobuta-1,3-diene

poly(2-chlorobuta-1,3-diene)

(i) Polymerisation of buta-1,3-diene, CH₂=CHCH=CH₂, occurs in the same way to form a synthetic rubber.

Draw the structural formula for poly(buta-1,3-diene).

[1]

(ii) The poly(2-chlorobuta-1,3-diene) shown in **equation 1.1** is the *cis*-stereoisomer.

Draw the structure of the *trans*-stereoisomer for poly(2-chlorobuta-1,3-diene).

[1]

(iii) Explain how the two stereoisomers for poly(2-chlorobuta-1,3-diene) occur.

4

(d)	The	reaction between 1 mol of buta-1,3-diene and 1 mol of hydrogen bromide is shown below.
	CH ₂	$_{2}$ =CHCH=CH $_{2}$ + HBr \rightarrow CH $_{2}$ =CHCHBrCH $_{3}$
	(i)	Name the mechanism of this reaction.
		[1]
	(ii)	Draw the mechanism for this reaction.
		Show curly arrows and full and partial charges.

_		
2	Solid barium carbonate	BaCO ₂ , is used as a rat poison.
_	Cona barrarri carboriato,	, bacca, io acca ac a rat polocii.

In a rat's stomach, barium carbonate reacts with the hydrochloric acid to produce soluble barium chloride, $BaCl_2$, which is poisonous.

(a) Write an equation for the reaction of solid barium carbonate with hydrochloric acid. Carbon dioxide is produced in the reaction.

Include state symbols.

[2]

(b) (i) Barium carbonate produces carbon dioxide gas when heated strongly. Calcium carbonate is less thermally stable.

Describe an experiment, using limewater, that you could do to show this.

Include a labelled diagram, how you would make it a valid test and what you would observe.

 71

6

(ii) A student attempts to explain why the thermal stability of the Group 2 carbonates increases down the Group.

		The student says it is because the Group 2 metals increase in chemical reactivity down the group. The carbonates of the more reactive elements decompose less easily when heated.
		Discuss the student's explanation, giving the correct chemistry where necessary.
		[9]
(c)	The	presence of calcium in its compounds may be identified using a flame test.
	(i)	Give the flame colour for calcium.
		[1]
	(ii)	The visible atomic emission spectrum of an element consists of a series of coloured lines on a black background.
		A section of this spectrum for calcium is shown in the diagram.
		6.20
		wavelength/m (×10 ⁻⁷)
		Calcium can also be identified using its atomic absorption spectrum.
		Describe the appearance of the visible atomic absorption spectrum of calcium and how it is related to the emission spectrum above.
		[2]

(iii)	Calculate the energy change of an electron, in kJ, that causes the line at 6.20×10^{-7} m in
	the spectrum of calcium.

energy change = kJ [3]

		8
(d)	A st	sudent uses a titration to measure the solubility of calcium hydroxide, Ca(OH) ₂ .
	hyd	e student uses a volumetric pipette to transfer 25.0 cm ³ of a saturated solution of calcium roxide into a conical flask. A saturated solution is used because it contains the maximum as of solute in a given volume of solution.
	(i)	The uncertainty in using a 25.0 cm ³ pipette is 0.06 cm ³ .
		Calculate the percentage uncertainty in using this pipette.
		percentage uncertainty = % [1]
	(ii)	The student titrates the $25.0\mathrm{cm^3}$ of saturated $\mathrm{Ca(OH)_2}$ with hydrochloric acid of concentration $0.100\mathrm{moldm^{-3}}$.
		$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$
		A mean titre of 11.70 cm ³ is obtained.
		Calculate the concentration of the saturated calcium hydroxide solution in g dm ⁻³ .
		concentration = g dm ⁻³ [4]
(e)		e titration described in part (d) is repeated with 25.0 cm ³ of saturated barium hydroxide ution.
		gest how the mean titre of 0.100 mol dm ⁻³ hydrochloric acid would differ from that for the urated calcium hydroxide solution. Explain your answer.

.....[1]

3 Parabens are compounds used as preservatives in some cosmetics.

A paraben can be made from the reaction between 4-hydroxybenzoic acid and ethanoic anhydride.

(a) 4-hydroxybenzoic acid has the following structural formula.

4-hydroxybenzoic acid reacts with both sodium hydroxide and sodium carbonate solutions.

The reaction with sodium hydroxide gives a compound with the molecular formula C₇H₄O₃Na₂.

The reaction with sodium carbonate gives a compound with the molecular formula C₇H₅O₃Na.

Use acid-base chemistry to explain these observations and include the structural formula for the organic product of each reaction.

[3]	

(b) A student makes 4-acetoxybenzoic acid in the laboratory by heating 4-hydroxybenzoic acid and ethanoic anhydride under reflux.

$$HO \longrightarrow OH + (CH_3CO)_2O \longrightarrow H_3C \longrightarrow OH + CH_3COOH$$

4-hydroxybenzoic acid

4-acetoxybenzoic acid

The reaction from (b) is shown again here.

$$HO \longrightarrow OH + (CH_3CO)_2O \longrightarrow H_3C \longrightarrow OH + CH_3COOH$$

4-hydroxybenzoic acid $M_r = 138$

4-acetoxybenzoic acid $M_r = 180$

(ii) The student reacts 3.5 g of 4-hydroxybenzoic acid with an excess of ethanoic anydride. After purifying the crude product the student obtains 2.8 g of 4-acetoxybenzoic acid.

Calculate the percentage yield of 4-acetoxybenzoic acid.

Give your answer to an appropriate number of significant figures.

(c) Give the name of the functional group enclosed by the dashed line in the structure of 4-acetoxybenzoic acid.

.....[1]

(d) 4-acetoxybenzoic acid has a melting point of 193 °C.

A student explains the high melting point as follows:

- Oxygen is more electronegative than carbon so the carbon-oxygen double bond will be polar.
- Strong permanent dipole-permanent dipole attractions occur between $C^{\delta+}$ and $O^{\delta-}$ atoms at either end of neighbouring molecules.

	Discuss the student's statements, giving the correct chemistry where necessary.
	[3]
(e)	Describe a simple test-tube reaction that would distinguish between 4-hydroxybenzoic acid and 4-acetoxybenzoic acid.
	[1]
(f)	4-acetoxybenzoic acid is much more soluble in hot ethanol than cold ethanol.
	Using this information, describe how to obtain a pure dry sample of 4-acetoxybenzoic acid from the crude product.
	[4]

(g)* The hydrolysis of parabens into 4-hydroxybenzoic acid may occur in slightly acidic or slightly alkaline household wastewater.

Some students investigate this hydrolysis. They make 4 solutions:

- a slightly alkaline solution of 4-acetoxybenzoic acid, X
- a slightly acidic solution of 4-acetoxybenzoic acid, Y
- a solution of pure 4-acetoxybenzoic acid, P
- a solution of pure 4-hydroxybenzoic acid, B

They run thin layer chromatograms of X, P and B (Fig. 3.1) and Y, P and B (Fig. 3.2).

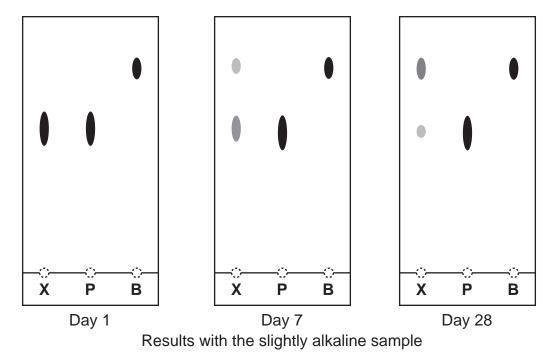


Fig. 3.1

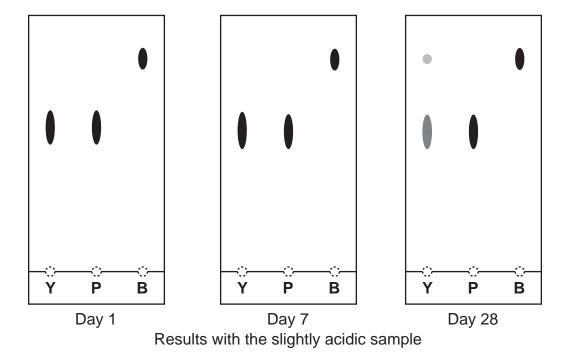


Fig. 3.2

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The chromatograms shown in **Fig. 3.1** and **Fig. 3.2** are for samples taken from the 4 solutions on day 1, day 7 and day 28.

Describe how to produce one of these thin layer chromatograms and explain what all the results show. [6]
Additional answer space if required

14 BLANK PAGE

4	Sodium hydrogencarbonate is used in baking powder. When it is heated above about 80°C	jt
	begins to break down as shown in equation 4.1 .	

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$
 Equation 4.1

The enthalpy change for the thermal decomposition of sodium hydrogenicarbonate, ΔH_1 , is difficult to determine directly by experiment.

Instead the enthalpy change for the reaction is determined indirectly using Hess' law.

The enthalpy changes ΔH_2 and ΔH_3 are determined separately.

$$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$$
 Equation 4.2

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$
 Equation 4.3

(a) Suggest why it is difficult to measure ΔH_1 directly.

[43]

(b) A student does an experiment to measure ΔH_2 .

The student adds 7.50 × 10^{-2} mol of NaHCO $_3$ to 50.00 cm 3 (an excess) of 2.00 mol dm $^{-3}$ HCl. The temperature **decreases** by 7.50 °C.

Use this data to calculate ΔH_2 in kJ per mol of NaHCO₃.

Assume the density and the specific heat capacity of the solution are the same as those of water.

$$\Delta H_2 =$$
 kJ mol⁻¹ [2]

(c)* Another student does an experiment to measure ΔH_3 .

The student uses a measuring cylinder to place $50\,\mathrm{cm^3}$ (an excess) of $2.00\,\mathrm{mol}\ \mathrm{dm^{-3}}\ \mathrm{HC}\,l$ into a glass beaker.

The student measures the temperature of the acid using a thermometer, taking readings to the nearest degree °C.

 $3.0\,\mathrm{g}$ of $\mathrm{Na_2CO_3}$ is added to the acid. The temperature increases slowly and the student records the temperature every minute.

The student uses the highest temperature reached (an increase of 5 °C) to calculate ΔH_3 .

The student wants to repeat the experiment to get a more accurate measurement of ΔH_3 .

Describe how measurement uncertainties and the effects of 'heat loss' can be reduced in the experiment. [6]
Additional answer space if required

(d)	In separate accurately performed experiments the following determined.	ng enthalpy changes were
	$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$	$\Delta H_2 = +23 \mathrm{kJ} \mathrm{mol}^{-1}$
	$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$	$\Delta H_3 = -30 \mathrm{kJ} \mathrm{mol}^{-1}$
	Draw a Hess' law enthalpy cycle and use these values for ΔH_2 for ΔH_1 .	and ΔH_3 to calculate a value
	$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(I)$	ΔH_1

enthalpy change $\Delta H_1 = \dots kJ \text{ mol}^{-1}$ [4]

(e) Bond enthalpies can be used in some calculations involving ΔH values. Use the data below to calculate a value for the bond enthalpy of the H–O bond.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g) \quad \Delta H = -484 \text{ kJ mol}^{-1}$$

Bond	Bond enthalpy/kJ mol ⁻¹
H–H	+436
O=O	+498

	bond enthalpy of H-O =		kJmol ⁻¹ [2]
(f)	Why can bond enthalpies not be used to estimate ΔH_1	?	
	$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(I)$	ΔH_1	
			[1]

END OF QUESTION PAPER

19 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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