Gold Paper
AS & A Level

Question Paper 2

Level	A Level
Subject	Chemistry
Exam Board	OCR
Paper	AS & A Level
Booklet	Question Paper 2

Time allowed: **89 minutes**

Score: **/66**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

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Silicon can be made by heating silicon tetrachloride, $SiCl_4$, with zinc.

$$SiCl_4 + 2Zn \rightarrow Si + 2ZnCl_2$$

8.50 g of $SiCl_4$ is reacted with an excess of zinc. The percentage yield of silicon is 90%.

What is the mass of silicon made?

A 1.26 g

B 1.31 g

C 1.40 g

D 1.55 g

[1]

Question 2

Which compound(s) is a/are structural isomer(s) of $C_6H_{12}O_2$?

1 hexanoic acid

2 ethyl butanoate

3 propyl propanoate

A. 1, 2 and 3

B. Only 1 and 2

C. Only 2 and 3

D. Only 1

[1]

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Which element has atoms with the greatest number of singly occupied orbitals?

A. C

B. C*l*

C. Ca

D. Ga

[1]

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$50.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ NaOH is neutralised by $50.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ HNO_3.
The temperature increases by 6.0 °C.

The experiment is repeated using:
$25.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ NaOH and $25.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ HNO_3.

What is the increase in temperature in the second experiment?

A 1.5 °C

B 3.0 °C

C 6.0 °C

D 12.0 °C

[1]

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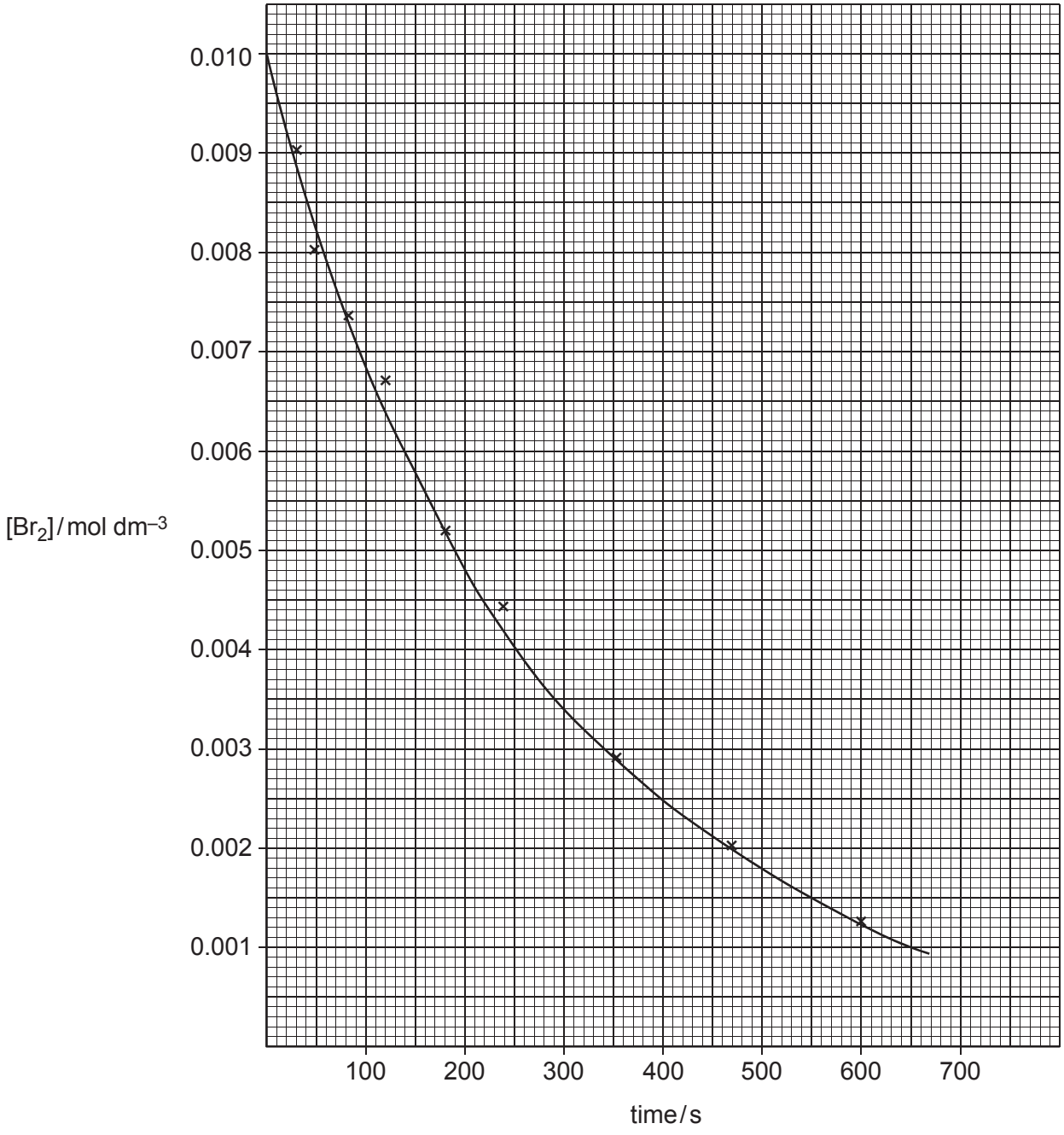
In aqueous solution, methanoic acid, HCOOH, reacts with bromine, Br_2.

$$HCOOH(aq) + Br_2(aq) \longrightarrow 2H^+(aq) + 2Br^-(aq) + CO_2(g)$$

A student carried out an investigation on the rate of this reaction. The student used a large excess of methanoic acid which ensured that its concentration was effectively constant throughout. During the reaction, bromine is used up and its orange colour becomes less intense. The intensity of the bromine colour can be measured with a colorimeter to give the bromine concentration.

The graph below was plotted from the experimental results.



In this investigation, a large excess of methanoic acid was used. Under these conditions, the reaction is effectively zero-order with respect to methanoic acid.

- Using the graph, determine the order of reaction with respect to bromine.
- Using the graph, determine the initial rate of the reaction.
- Calculate the rate constant, *k*, for the reaction between methanoic acid and bromine under these conditions.

In your answer you should make clear how your conclusions fit with the experimental results, including working shown on the graph and units where appropriate.

[9]

[Total 9 Marks]

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Chemists and biochemists use pK_a values to compare the strengths of different acids. pK_a is a more convenient way of comparing acid strengths than K_a values.

pK_a values of several naturally occurring Brønsted–Lowry acids are shown in **Table 4.1** below.

common name and source	systematic name	structural formula	pK_a (at 25°C)
benzoic acid (from bark resin)	benzenecarboxylic acid	C_6H_5COOH	4.19
acetic acid (from vinegar)	ethanoic acid	CH_3COOH	4.76
pyruvic acid (formed during metabolism)	2-oxopropanoic acid	$CH_3COCOOH$	2.39
lactic acid (from milk)	2-hydroxypropanoic acid	$CH_3CHOHCOOH$	3.86

Table 4.1

(a) (i) What is meant by the term *Brønsted–Lowry acid*? [1]

(ii) What is meant by the *strength* of an acid?

In your answer, include an equation for one of the acids in **Table 4.1**. [2]

(iii) Place the four acids in **Table 4.1** in order of increasing strength.

weakest acid

↓

strongest acid [1]

(iv) Aqueous benzoic acid was mixed with aqueous lactic acid. An equilibrium mixture was formed containing conjugate acid–base pairs.

Complete the equilibrium below to show the components in the equilibrium mixture.

$C_6H_5COOH + CH_3CHOHCOOH \rightleftharpoons$ ..... + ... [1]

(b) Aqueous pyruvic acid was reacted with an aqueous solution of calcium hydroxide.

(i) Write an equation for this reaction. [1]

(ii) Write an ionic equation for this reaction. [1]

(c) The pH of an acid solution can be calculated from its pK_a value.

Calculate the pH of a 0.0150 mol dm^{-3} solution of pyruvic acid at 25 °C.

Show **all** your working.
Give the pH to **two** decimal places. [4]

(d) Oxalic acid (ethanedioic acid), $C_2H_2O_4$, is present in the leaves of rhubarb plants. Oxalic acid has two dissociations with pK_a = 1.23 and pK_a =4.19.

(i) Draw the structure of oxalic acid. [1]

(ii) Predict the equations that give rise to each dissociation.

pK_a = 1.23

pK_a = 4.19 [2]

(e) The 'magic tang' in many sweets is obtained by use of acid buffers. A sweet manufacturer carried out tasting tests with consumers and identified the acid taste that gives the 'magic tang' to a sweet.

The manufacturer was convinced that the 'magic tang' would give the company a competitive edge and he asked the company's chemists to identify the chemicals needed to generate the required taste. The chemists' findings would be a key factor in the success of the sweets.

The team of chemists identified that a pH of 3.55 was required and they worked to develop a buffer at this pH.

The chemists decided to use one of the acids in **Table 4.1** (page 8) and a salt of the acid to prepare this buffer.

- Deduce the chemicals required by the chemists to prepare this buffer.
- Calculate the relative concentrations of the acid and its salt needed by the chemist to make this buffer.
- Comment on the validity of the prediction that the pH of the sweet would give the sweets the 'magic tang'.

[6]

[Total 20 Marks]

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Lattice enthalpies can be calculated indirectly using Born–Haber cycles.

Table 2.1 shows enthalpy changes needed to calculate the lattice enthalpy of sodium oxide, Na_2O.

letter	enthalpy change	energy /kJ mol^{-1}
A	1st electron affinity of oxygen	–141
B	2nd electron affinity of oxygen	+790
C	1st ionisation energy of sodium	+496
D	atomisation of oxygen	+249
E	atomisation of sodium	+108
F	formation of sodium oxide	–414
G	lattice enthalpy of sodium oxide	

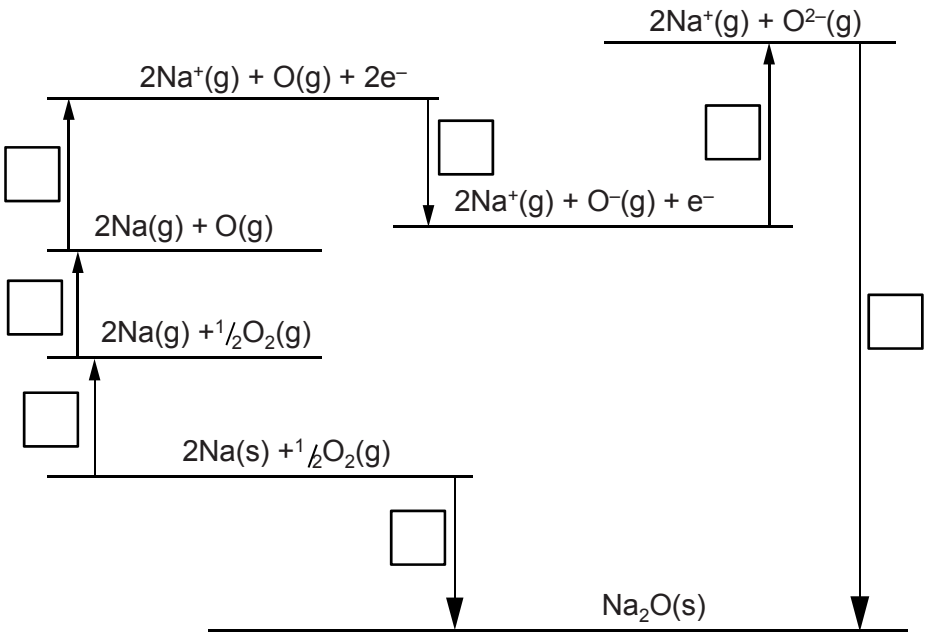
Table 2.1

(a) Define the term *lattice enthalpy*. [2]

(b) The Born–Haber cycle below links the lattice enthalpy of sodium oxide with its enthalpy change of formation.

(i) On the Born–Haber cycle, write the correct letter from **Table 2.1** in each box.

[3]



(ii) Calculate the lattice enthalpy of sodium oxide, **G**. [2]

(c) Explain why it is difficult to predict whether the lattice enthalpy of magnesium sulfide would be more or less exothermic than the lattice enthalpy of sodium oxide. [3]

(d) A student wanted to determine the lattice enthalpy of sodium carbonate, Na_2CO_3. Unfortunately this is very difficult to do using a similar Born–Haber cycle to that used for sodium oxide in **(b)**.

(i) Suggest why this is very difficult. [1]

(ii) The student thought that he could determine the lattice enthalpy of Na_2CO_3 using a Born–Haber cycle that links lattice enthalpy with enthalpy change of solution.
The enthalpy change of solution of Na_2CO_3 is exothermic.

- Sketch this Born–Haber cycle,
- Explain how the lattice enthalpy of Na_2CO_3 could be calculated from the enthalpy changes in the cycle.

[3]

[Total 14 Marks]

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Chlorine, bromine and iodine are halogens commonly used in school and college experiments.

(a) Halogens have van der Waals' forces between their molecules.

(i) Describe how van der Waals' forces arise. [3]

(ii) State **and** explain the trend in the boiling points of chlorine, bromine and iodine. [3]

(b) The halogen astatine does **not** exist in large enough quantities to observe any of its reactions.

Why would astatine be expected to react similarly to other halogens? [1]

(c) A student investigated the reactivity of halogens by attempting some redox reactions.

(i) The student added bromine water to aqueous solutions of sodium chloride and sodium iodide in separate test-tubes. The student then added an organic solvent, cyclohexane, to each test-tube and these were shaken.

- State what colour you would see in the cyclohexane in each test-tube after shaking.
- Write **ionic** equations for any chemical reactions that take place.
- State and explain the trend in reactivity shown by these observations.

In your answer you should use appropriate technical terms spelled correctly. [6]

(ii) Suggest why the student carried out the reactions in a well ventilated area. [1]

(d) The halogen fluorine is too reactive to use in a school or college laboratory. Fluorine is a powerful oxidising agent. It will react with water as shown below.

(i) Complete and balance the equation for the reaction of fluorine with water.

$F_2(g)$ + $H_2O(l)$ $\rightarrow$ + $O_2(g)$ [1]

(ii) Using oxidation numbers, show what has been oxidised and what has been reduced in this reaction. [2]

(e) Fluorine will react violently with gallium to produce gallium fluoride.

Mendeleev originally called gallium 'eka-aluminium' as he predicted that gallium would have similar properties to aluminium.

(i) Complete the electron structure of the gallium atom.

$1s^2$ [1]

(ii) Use Mendeleev's prediction to suggest the empirical formula of gallium fluoride.

[1]

[Total: 19 Marks]