AQA

SPECIMEN MATERIAL v1.2

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level CHEMISTRY

Paper 1: Inorganic and Physical Chemistry

Specimen materials (set 2)

Time allowed: 2 hours

Materials

For this paper you must have:

- the Periodic Table/Data Booklet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of the page.
- Answer **all** questions.
- You must answer the questions in the spaces provided.
  Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book.
  Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 105.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
TOTAL	

Answer **all** questions in the spaces provided.

0 1 This question is about the chemistry of some Group 2 elements.

0 1 . 1 Write an equation for the reaction of calcium with water at 25 °C and predict a possible value for the pH of the solution formed.

[2 marks]

Equation

pH

0 1 . 2 State the trend in solubility, in water, of the Group 2 sulfates from magnesium to barium.

[1 mark]

0 1 . 3 State a reagent that can be used to test for the presence of sulfate ions and write a simple ionic equation for the reaction that occurs with the chosen reagent.

[2 marks]

Reagent

Equation

0 1 . 4 Explain why the melting point of calcium sulfate is high.

[2 marks]

7

0 2 The following tests were carried out to identify an unknown green salt **Y**.

An aqueous solution of **Y** gave a cream precipitate of compound **A** when reacted with silver nitrate solution.

Compound **A** gave a colourless solution when reacted with concentrated ammonia solution.

Another aqueous solution of **Y** gave a green precipitate **B** when reacted with sodium carbonate solution.

The green precipitate **B** was filtered and dried and then reacted with sulfuric acid to give a pale green solution containing compound **C** and a colourless gas **D**.

0 2 . 1 Identify by name or formula the compounds **A**, **B**, **C**, **D** and **Y**.

[5 marks]

Identity of **A** _____

Identity of **B** _____

Identity of **C** _____

Identity of **D** _____

Identity of **Y** _____

0 2 . 2 Write the simplest ionic equation for the reaction of silver nitrate solution with the anion that is present in compound **Y**.

[1 mark]

_____

0 2 . 3 Write the simplest ionic equation for the reaction that occurs between the green precipitate **B** and sulfuric acid.

[1 mark]

_____

7

0 3 This question is about the element iodine and its compounds.

0 3 . 1 Iodine is in Group 7 of the Periodic Table.

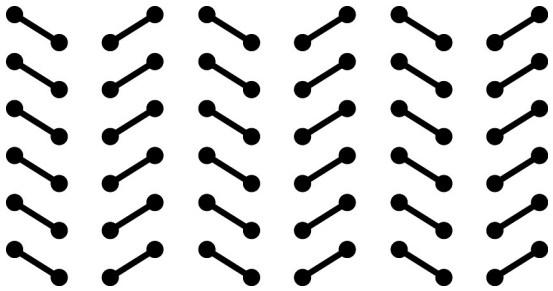
Complete the electron configuration of an iodine atom.

[1 mark]

[Kr] _____

0 3 . 2 Part of the structure of an iodine crystal is shown in **Figure 1**.

Figure 1



Use your knowledge of structure and bonding to explain why the melting point of iodine is low (113.5 °C) and why that of hydrogen iodide is very low (–50.8 °C).

[6 marks]

0 3 . 3 State why iodine does **not** conduct electricity.

[1 mark]

0 3 . 4 Deduce an equation for the formation of hydrogen iodide from its elements.

[1 mark]

Question 3 continues on the next page

0 3 . 5 The triiodide ion is formed when an iodine molecule is bonded to an iodide ion.

What is the formula of ammonium triiodide?

Tick (✓) **one** box.

[1 mark]

NH_3I_3 ☐

NH_3I_4 ☐

NH_4I ☐

NH_4I_3 ☐

0 3 . 6 Draw the shape of the IF_3 molecule and the shape of the IF_4^- ion.
Include any lone pairs of electrons that influence each shape.

[2 marks]

0 3 . 7 Deduce the oxidation state of iodine in the following species.

[2 marks]

$Ba(IO_3)_2$ _____

$[H_4IO_6]^-$ _____

14

0 4 Iron forms many complexes that contain iron in oxidation states +2 and +3.

0 4 . 1 Hexaaquairon(III) ions react with an excess of hydrochloric acid in a ligand substitution reaction.

Write an equation for this reaction.

[1 mark]

0 4 . 2 Explain why the initial and final iron(III) complexes in the equation in Question **04.1** have different shapes.

[2 marks]

0 4 . 3 Hexaaquairon(II) ions react with an excess of $H_2NCH_2CH_2NH_2$ in a ligand substitution reaction.

Draw the structure of the iron(II) complex formed showing its charge.

[2 marks]

Question 4 continues on the next page

0 4 . 4 Hexaaquairon(II) ions react with an excess of $H_2NCH_2CH_2NH_2$ in a ligand substitution reaction.

Which of the following shows the correct change in entropy for a reaction of hexaaquairon(II) ions with $H_2NCH_2CH_2NH_2$?

Tick (✓) **one** box.

[1 mark]

change in entropy is negative ☐

change in entropy is close to zero ☐

change in entropy is positive ☐

0 4 . 5 The percentage of iron(II) sulfate in iron tablets can be determined by titration with potassium manganate(VII) in acidic solution.

Deduce an ionic equation for the reaction of iron(II) ions with manganate(VII) ions.

[1 mark]

_____

0 4 . 6 A student dissolved 1980 mg of iron tablets in an excess of dilute sulfuric acid. The solution was titrated with 0.0200 mol dm^{-3} potassium manganate(VII) solution. A 32.50 cm^3 volume of potassium manganate(VII) solution was required to reach the end point in the titration.

Calculate the percentage of iron in the sample of iron tablets.
Give your answer to the appropriate number of significant figures.

[4 marks]

Percentage _____ %

0 4 . 7 State the colour change at the end point in this titration.

[1 mark]

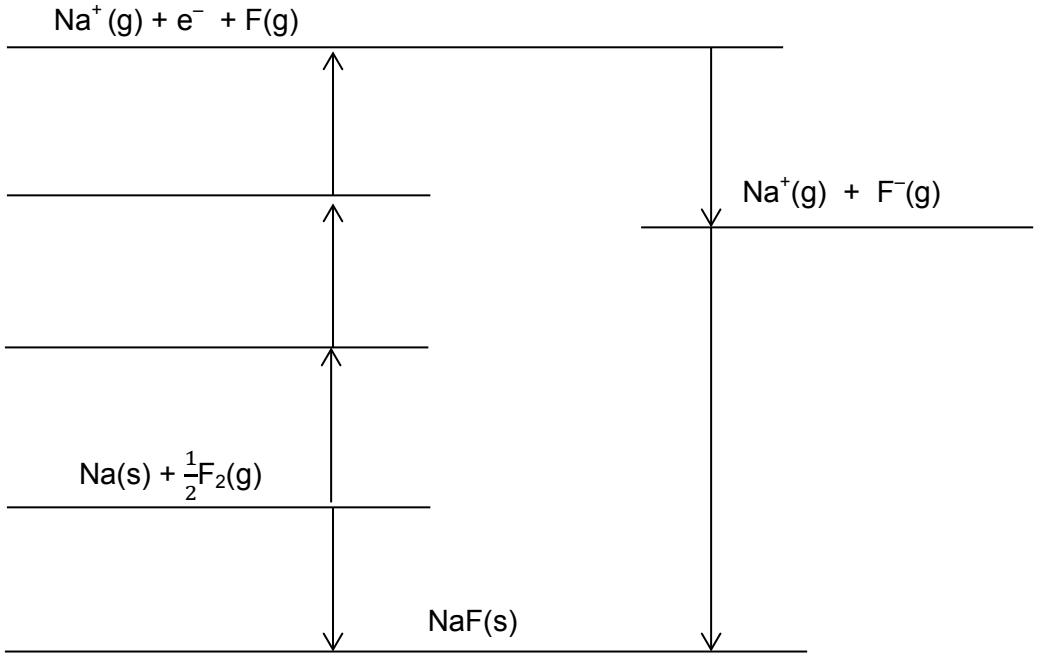
_____

12

0 5 This question is about sodium fluoride.

0 5 . 1 Complete the Born–Haber cycle for sodium fluoride by adding the missing species on the lines.

[2 marks]



0 5 . 2 Use the data in **Table 1** and your completed Born–Haber cycle from Question **05.1** to calculate the enthalpy of lattice formation of sodium fluoride.

[2 marks]

Table 1

	$\Delta H^{\ominus}$ / kJ mol^{-1}
$Na(s) \longrightarrow Na(g)$	+109
$Na(g) \longrightarrow Na^+(g) + e^-$	+494
$F_2(g) \longrightarrow 2F(g)$	+158
$F(g) + e^- \longrightarrow F^-(g)$	–348
$Na(s) + \frac{1}{2}F_2(g) \longrightarrow NaF(s)$	–569

Enthalpy of lattice formation _____ kJ mol^{-1}

0 5 . 3 Suggest how the enthalpy of lattice formation of NaCl compares with that of NaF

Justify your answer.

[3 marks]

How enthalpies of formation compare _____

_____

Justification _____

_____

_____

_____

_____

0 5 . 4 Calculate the volume, in cm^3, of fluorine gas at 298 K and 100 kPa required to produce 1.00 g of sodium fluoride by reaction with an excess of sodium.

The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$

[4 marks]

Volume _____ cm^3

11

0 6 **Table 2** shows some standard electrode potential data.

Table 2

Electrode half-equation	$E^{\ominus}$ / V
$Cl_2(g) + 2e^- \longrightarrow 2Cl^-(aq)$	+1.36
$Ag^+(aq) + e^- \longrightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$	+0.77
$Sn^{2+}(aq) + 2e^- \longrightarrow Sn(s)$	–0.14
$Fe^{2+}(aq) + 2e^- \longrightarrow Fe(s)$	–0.44

0 6 . 1 Use data from **Table 2** to deduce the species that is the best oxidising agent.

[1 mark]

0 6 . 2 Write the conventional representation for the cell used to measure the standard electrode potential for the conversion of tin(II) ions to tin.

[2 marks]

0 6 . 3 A cell was made by connecting two half-cells with a salt bridge. One half-cell consisted of silver in a solution of silver nitrate solution and the other consisted of tin in a solution of tin(II) nitrate solution.

Calculate the EMF of this cell and write a half-equation for the reaction that occurs at the negative electrode.

[2 marks]

EMF

Half-equation

0 6 . 4 Use data from **Table 2** to write an equation for the reaction of silver(I) ions with iron(II) ions.

[1 mark]

6

Turn over for the next question

0 7 Hydrogen can be manufactured by the reaction of methane with steam. An equilibrium is established as shown by the equation.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

0 7 . 1 Use Le Chatelier's principle to predict the effect on the equilibrium yield of hydrogen if the overall pressure is increased.
Explain your answer.

[3 marks]

Effect on yield _____

Explanation _____

_____

_____

_____

0 7 . 2 Explain why the equilibrium yield of hydrogen is unchanged if a catalyst is used in the reaction.

[2 marks]

_____

_____

_____

_____

_____

0 7 . 3 **Table 3** shows the standard enthalpy of formation and the standard entropy for each substance in this equilibrium reaction.

Table 3

	$CH_4(g)$	$H_2O(g)$	$CO(g)$	$H_2(g)$
$\Delta_f H^{\ominus}$ / kJ mol^{-1}	–75	–242	–111	0
$S^{\ominus}$ /J K^{-1} mol^{-1}	186	189	198	131

Use data from **Table 3** to calculate the standard enthalpy change for this equilibrium reaction.

[2 marks]

Standard enthalpy change _____ kJ mol^{-1}

0 7 . 4 Use your answer from Question **07.3** and the entropy data from **Table 3** to calculate the minimum temperature, in °C, needed for this reaction to be feasible.
Give your answer to the appropriate number of significant figures.

(If you did not complete Question **07.3** you should assume a value of 120 kJ mol^{-1} for the standard enthalpy change. This is **not** the correct value).

[5 marks]

Minimum temperature _____ °C

0 8 This question is about Brønsted–Lowry acids.

0 8 . 1 Give the meaning of the term Brønsted–Lowry acid.

[1 mark]

0 8 . 2 What is meant by the term strong when describing an acid?

[1 mark]

0 8 . 3 At 298 K, 25.0 cm^3 of a solution of a strong monoprotic acid contained 1.45×10^{-3} mol of hydrogen ions.

Calculate a value for the pH of this solution.
Give your answer to 2 decimal places.

[2 marks]

pH _____

0 8 . 4 Calculate the pH of the solution formed after the addition of 35.0 cm^3 of 0.150 mol dm^{-3} NaOH to the original 25.0 cm^3 of monoprotic acid.

The ionic product of water $K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6} at 298 K.
Give your answer to two decimal places.

[5 marks]

pH _____

Question 8 continues on the next page

0 8 . 5 A buffer solution is made when 1.50 g of sodium hydroxide are added to 1.00 dm^3 of a 0.150 mol dm^{-3} solution of a weak acid HA.

For HA, the acid dissociation constant, $K_a = 1.79 \times 10^{-5}$ mol dm^{-3}.

Calculate the pH of this buffer solution.

[6 marks]

pH _____

15

Turn over for the next question

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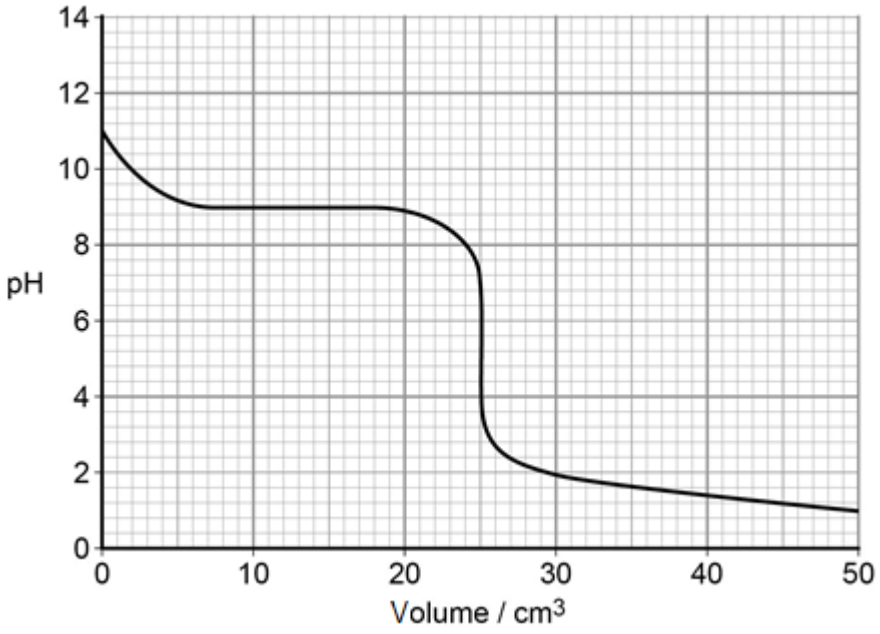
ANSWER IN THE SPACES PROVIDED

0 9 The graph in **Figure 2** was obtained from an experiment in which an acid was reacted with an alkali.

Figure 2



0 9 . 1 Suggest possible formulae for an acid and an alkali that could be used to produce the curve shown in **Figure 2**.

[2 marks]

Acid _____

Alkali _____

0 9 . 2 Suggest briefly a practical procedure that a student could use to obtain data from which the curve in **Figure 2** could be plotted.

[3 marks]

_____

_____

_____

_____

_____

_____

_____

0 9 . 3 The student was provided with samples of three different indicators.

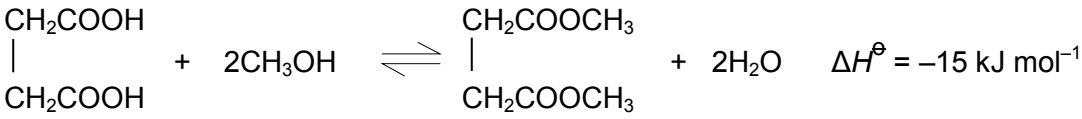
Suggest how the practical procedure in Question **09.2** could be refined by the student to identify the most suitable indicator.

[2 marks]

7

Turn over for the next question

1 0 Acid **X** reacts with methanol to form an ester **Y**.



X **Y**

1 0 . 1 Write an expression for the equilibrium constant, K_c, for this reaction. Use **X** and **Y** in your expression.

[1 mark]

1 0 . 2 A mixture of 0.32 mol of acid **X** and 0.84 mol of CH_3OH was allowed to reach equilibrium in the presence of a small amount of catalyst.
The equilibrium mixture formed contained 0.26 mol of ester **Y**.

Calculate the amounts, in moles, of **X**, CH_3OH and H_2O in this equilibrium mixture.

[3 marks]

Amount of **X** _____

Amount of CH_3OH _____

Amount of H_2O _____

1 0 . 3 Calculate the value of K_c and state the units.

[3 marks]

K_c _____ units _____

1 0 . 4 Predict the effect on K_c if the reaction is carried out at a lower temperature.

[1 mark]

8

1 1 This question is about time of flight (TOF) mass spectrometry.

1 1 . 1 The mass spectrum of element **Q** has peaks with *m*/*z* values shown in **Table 4**.

Table 4

m/z	82	83	84	86
Relative intensity	5	3	26	7

Calculate the relative atomic mass of **Q** and give your answer to one decimal place.
Identify the element **Q**.

[3 marks]

Relative atomic mass of **Q** _____

Element **Q** _____

Question 11 continues on the next page

1 1 . 2 A sample of the element **Q** consists of several isotopes. All of the $\mathbf{Q}^+$ ions in the sample of **Q** that has been ionised in a TOF mass spectrometer have the same kinetic energy.

kinetic energy of each ion = $\frac{1}{2}mv^2$

where m is the mass, in kg, of one ion of an isotope
and v is the velocity of an ion in m s^{-1}

$v = \frac{d}{t}$

where d is the length, in m, of the flight tube
and t is the time taken, in s, for an ion to reach the detector

The time of flight of a $^{82}\mathbf{Q}^+$ ion is 1.243×10^{-5} s.

Calculate the time of flight of the $^{86}\mathbf{Q}^+$ ion.

[3 marks]

Time of flight of the $^{86}\mathbf{Q}^+$ ion _____ s

6

END OF QUESTIONS