Rewarding Learning

Centre Number

Candidate Number

General Certificate of Secondary Education
2023

GCSE Chemistry

Unit 2

Higher Tier

[GCM22]

GCM22

TUESDAY 13 JUNE, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in blue or black ink only. **Do not write with a gel pen.**
Answer **all five** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
Quality of written communication will be assessed in question **5(a)**.
A Data Leaflet, which includes a Periodic Table of the Elements, is included in this question paper.

13552

1 Some metals react with oxygen in the air and with cold water.

(a) Complete the following table giving information about the reactions of the metals potassium and copper with oxygen in the air and with cold water.

	Potassium	**Copper**
Three observations when the metal is heated in air	grey solid metal burns with a lilac flame white solid forms	
Balanced symbol equation for the reaction of the metal with oxygen		$2Cu + O_2 \rightarrow 2CuO$
Three observations during the reaction of the metal with cold water		no reaction
Balanced symbol equation for the reaction of the metal with cold water		

[12]

(b) Copper is a valuable metal and is used in large quantities. However, reserves of copper ore are becoming very scarce and other methods of extracting copper have been developed. One such method is phytomining.

Describe the process of phytomining in four steps.

Step 1: _____

_____

_____

Step 2: _____

_____

_____

Step 3: _____

_____

_____

Step 4: _____

_____

_____ [4]

[Turn over

(c) Displacement reactions may be used to establish a reactivity series of metals.

Several experiments were carried out using the metals lead, magnesium, zinc and silver. A sample of each metal was added to solutions of the metal nitrates. The results obtained are shown in the table below. A tick (✔) indicates that a reaction occurs.

Solution	**Metal**			
	Lead	Magnesium	Zinc	Silver
Lead(II) nitrate		✔	✔	✘
Magnesium nitrate	✘		✘	✘
Zinc nitrate	✘	✔		✘
Silver nitrate	✔	✔	✔	

(i) Use the results to put the metals in order of reactivity with the most reactive metal first.

most reactive: _____

_____

_____

least reactive: _____ [1]

(ii) Write a balanced symbol equation for the reaction between magnesium and silver nitrate solution.

[3]

(iii) The reaction between magnesium and zinc nitrate solution may be described as a redox reaction. Explain, in terms of electrons, why this reaction is a redox reaction.

[5]

[Turn over

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2 The industrial production of sulfuric acid occurs in several steps. The balanced symbol equation for one step involving the oxidation of sulfur dioxide to sulfur trioxide, SO_3, is given below. The forward reaction is exothermic.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(a) (i) This reaction is reversible. What do you understand by the term reversible?

_____

_____

_____ [1]

(ii) Explain, using Le Châtelier's Principle, why the equilibrium yield of sulfur trioxide (SO_3) decreases as temperature increases.

_____

_____

_____

_____

_____ [2]

(iii) Use Le Châtelier's Principle to state and explain how an increase in pressure will affect the equilibrium yield of sulfur trioxide (SO_3).

_____

_____

_____

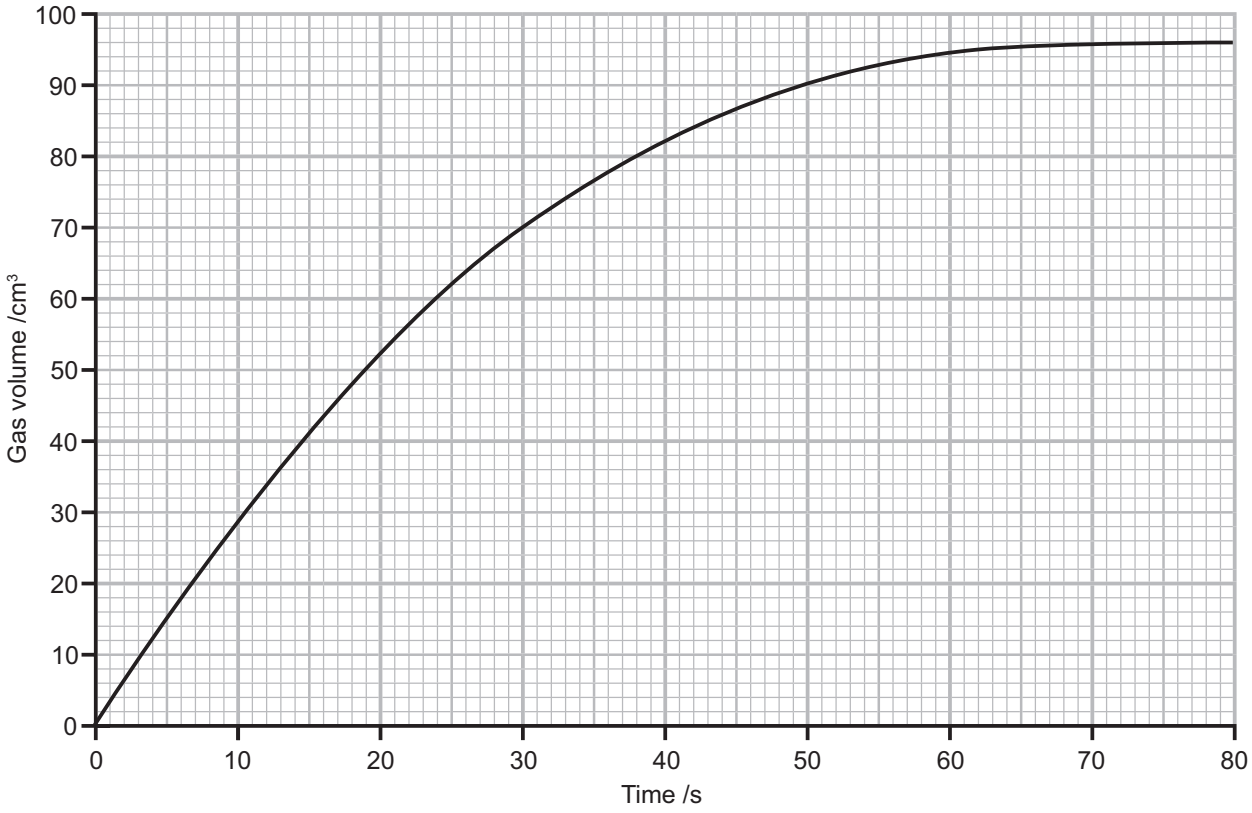
_____

_____ [3]

[Turn over

(b) Zinc metal reacts with dilute sulfuric acid to produce hydrogen gas.

0.26 g of zinc granules were added to 25.0 cm^3 of 0.50 mol/dm^3 sulfuric acid at room temperature (20 °C). The volume of gas produced was recorded every 10 seconds. The acid was in excess. The results are plotted on the graph below.



(i) Write a balanced symbol equation for the reaction between zinc and sulfuric acid. Include state symbols.

_____ [3]

(ii) The experiment was repeated using 0.26 g of zinc powder and 25.0 cm^3 of 0.50 mol/dm^3 sulfuric acid at room temperature. State and explain the effect this change will have on the rate of the reaction.

Effect: _____

Explanation: _____

_____

_____

_____ [4]

(c) Copper(II) sulfate may be used as a catalyst for the reaction of zinc with dilute sulfuric acid.

(i) Explain how a catalyst increases the rate of a chemical reaction.

_____

_____

_____ [2]

(ii) Sketch on the axes opposite, the graph obtained when the experiment in **(b)** is repeated with 1.0 g of copper(II) sulfate added. All other factors remain the same. Label this graph A. [1]

[Turn over

3 Crude oil is a mixture of hydrocarbons and is the main source of organic chemicals.

(a) **(i)** Name the process used to separate crude oil into its components.

_____ [2]

(ii) State the meaning of the term hydrocarbon.

_____

_____ [1]

(b) Most of the hydrocarbons obtained from crude oil belong to a homologous series named the alkanes.

(i) What is meant by the term homologous series?

_____

_____

_____

_____ [3]

(ii) Write the general formula of the alkanes.

_____ [1]

(c) Some of the large alkane molecules obtained from crude oil undergo the process of cracking. Cracking produces smaller, more useful hydrocarbons.

(i) Complete the balanced symbol equation below to show the cracking of the alkane, $C_{14}H_{30}$.

$$C_{14}H_{30} \rightarrow C_{12}H_{26} + \_\_\_\_\_$$ [1]

(ii) Draw a reaction profile diagram for the endothermic process of cracking. Label the axes and the activation energy.

[3]

(iii) State the meaning of the term activation energy.

_____

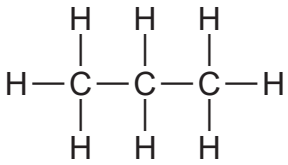
_____ [1]

[Turn over

(d) Alkanes are mainly used as fuels. The fuel in camping gas cylinders is a mixture of propane and butane.

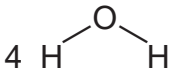
The balanced symbol equation for the complete combustion of propane is:

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$



5 O=O

3 O=C=O

4 

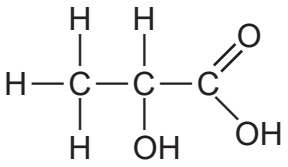
The energy change for the reaction is −2050 kJ.

Use the bond energies in the table below and the energy change for the combustion of propane to calculate a value for the bond energy of one C—C bond.

Bond	Bond energy /kJ
C—C	
C—H	412
O=O	496
C=O	803
O—H	463

C—C bond energy = _____ kJ [4]

(e) Lactic acid is a carboxylic acid that can build up in muscles during strenuous exercise causing cramps and fatigue. The structural formula of lactic acid is shown below.



(i) The molecular formula of lactic acid may be written as $C_xH_yO_z$. What are the values of x, y and z in this molecular formula?

x = _____ y = _____ z = _____ [1]

(ii) **Draw** a circle around the carboxylic acid functional group in lactic acid. [1]

(iii) Lactic acid is a weak acid. Explain the meaning of the term weak acid.

_____

_____ [1]

(iv) A sample of solid copper(II) carbonate was added to a solution of lactic acid. State three observations you would make during this reaction.

_____

_____

_____

_____ [3]

[Turn over

(f) Carboxylic acids may be formed when an alcohol, such as propan-1-ol, undergoes oxidation.

(i) Draw the structural formula of propan-1-ol.

[1]

(ii) Name a reagent that may be used to oxidise an alcohol to a carboxylic acid.

_____ [2]

(iii) Name the carboxylic acid formed when propan-1-ol undergoes oxidation.

_____ [1]

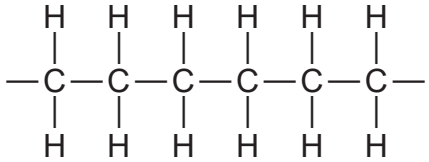
(g) Sportswear made of lycra can enhance performance and prevent the build-up of lactic acid in muscles. Lycra is made of a combination of polymers.

(i) What is meant by the term polymer?

_____

_____ [1]

(ii) Part of the structure of a polymer molecule is shown below.



Name this polymer.

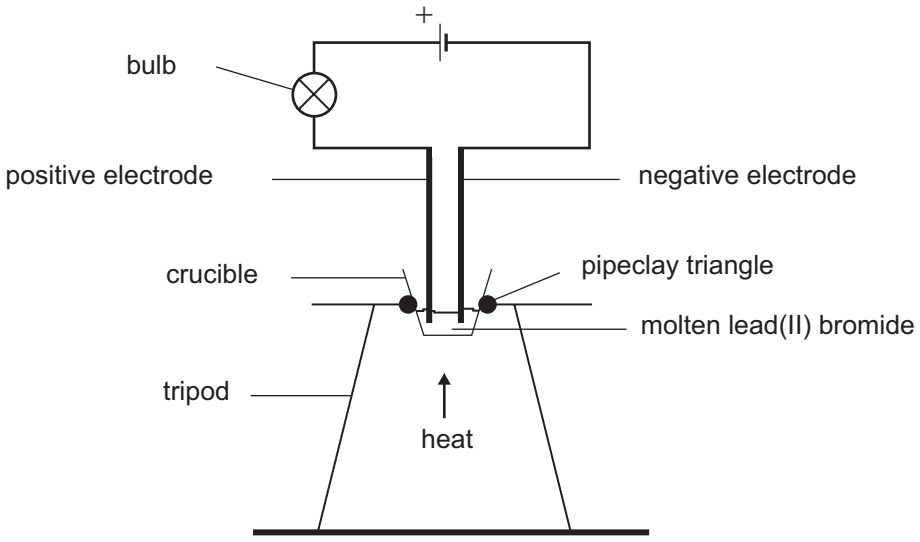
_____ [1]

(iii) Draw the structure of the monomer from which the polymer above is formed.

[1]

[Turn over

4 The diagram below shows the apparatus used to carry out the electrolysis of molten lead(II) bromide.



(a) (i) What name is used for a liquid that conducts electricity and is decomposed by it?

_____ [1]

(ii) How would you know the molten lead(II) bromide was conducting electricity?

_____

_____ [1]

(b) During the electrolysis of molten lead(II) bromide, $PbBr_2$, the half equation for the reaction occurring at the negative electrode is:

$$Pb^{2+} + 2e^- \rightarrow Pb$$

(i) Name the type of reaction shown in this equation.

_____ [1]

(ii) Write the half equation for the reaction occurring at the positive electrode.

_____ [3]

(iii) What is observed at the positive electrode during the electrolysis of molten lead(II) bromide?

_____

_____ [2]

[Turn over

(c) Molten lithium chloride also undergoes electrolysis.

(i) Write a word equation for the overall reaction which occurs during the electrolysis of molten lithium chloride.

_____ [1]

(ii) The electrodes used in the electrolysis of molten lithium chloride do not take part in the reaction. What term is used to describe electrodes that do not take part in an electrolysis reaction?

_____ [1]

(iii) Name a substance which could be used to make the electrodes in this electrolysis.

_____ [1]

(iv) Explain how molten lithium chloride conducts electricity.

_____

_____ [1]

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(Questions continue overleaf)

[Turn over

5 Hydrated salts contain water of crystallisation. The degree of hydration of some salts may be determined by titration.

(a) During this type of titration, a burette is used to add a solution of an acid to a conical flask which contains a solution of the hydrated salt and an indicator. Describe in detail:

- how the burette is prepared and filled with a solution of the acid and
- the steps taken to ensure accuracy when determining the end point of the titration.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

[6]

(b) A 6.0 g sample of hydrated sodium carbonate, $Na_2CO_3.xH_2O$, was dissolved in deionised water and the solution made up to 250 cm^3 in a volumetric flask.

25.0 cm^3 portions of this solution were titrated against 0.2 mol/dm^3 sulfuric acid. The average titre was found to be 24.2 cm^3.

The equation for the reaction is:

$$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$$

(i) Calculate the number of moles of sulfuric acid used.

moles of H_2SO_4 = _____ [1]

(ii) Calculate the number of moles of sodium carbonate present in 25.0 cm^3 of the solution.

moles of Na_2CO_3 in 25.0 cm^3 = _____ [1]

(iii) Calculate the number of moles of sodium carbonate present in 250 cm^3 of the solution.

moles of Na_2CO_3 in 250 cm^3 = _____ [1]

[Turn over

(iv) Using the initial mass of $Na_2CO_3.xH_2O$ and the answer to part **(b)(iii)**, calculate the relative formula mass (M_r) of $Na_2CO_3.xH_2O$. Give your answer to the nearest whole number.

relative formula mass (M_r) = _____ [1]

(v) Calculate the value of x in $Na_2CO_3.xH_2O$

x = _____ [1]

(c) Solid sodium hydrogencarbonate decomposes when heated. The equation for the reaction is:

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

3.36 g of sodium hydrogencarbonate were placed in a boiling tube and heated to constant mass. Calculate the volume of carbon dioxide gas, in dm^3, produced at 20 °C and 1 atm pressure in this reaction.

volume of carbon dioxide = _____dm^3 [3]

(d) Carbon dioxide is also produced during the complete combustion of hydrocarbons. The balanced equation for the combustion of pentane is:

$$C_5H_{12}(g) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(g)$$

Use Avogadro's Law to calculate the volume of CO_2 formed, in dm^3, when 150 dm^3 of pentane undergoes complete combustion.

volume of carbon dioxide = _____ dm^3 [1]

(e) Calcium hydroxide solution is used to test for carbon dioxide gas.

(i) State the common name for calcium hydroxide solution.

_____ [1]

(ii) Describe what would be observed when carbon dioxide gas is bubbled through calcium hydroxide solution until the carbon dioxide is in excess.

_____

_____

_____ [2]

THIS IS THE END OF THE QUESTION PAPER

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For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
Total Marks	

Examiner Number

GCM22/5
275757

SYMBOLS OF SELECTED IONS

Positive ions

Name	Symbol
Ammonium	NH_4^+
Chromium(III)	Cr^{3+}
Copper(II)	Cu^{2+}
Iron(II)	Fe^{2+}
Iron(III)	Fe^{3+}
Lead(II)	Pb^{2+}
Silver	Ag^+
Zinc	Zn^{2+}

Negative ions

Name	Symbol
Butanoate	$C_3H_7COO^-$
Carbonate	CO_3^{2-}
Dichromate	$Cr_2O_7^{2-}$
Ethanoate	CH_3COO^-
Hydrogencarbonate	HCO_3^-
Hydroxide	OH^-
Methanoate	$HCOO^-$
Nitrate	NO_3^-
Propanoate	$C_2H_5COO^-$
Sulfate	SO_4^{2-}
Sulfite	SO_3^{2-}

SOLUBILITY IN COLD WATER OF COMMON SALTS, HYDROXIDES AND OXIDES

Soluble
All sodium, potassium and ammonium salts
All nitrates
Most chlorides, bromides and iodides EXCEPT silver and lead chlorides, bromides and iodides
Most sulfates EXCEPT lead and barium sulfates Calcium sulfate is slightly soluble

Insoluble
Most carbonates EXCEPT sodium, potassium and ammonium carbonates
Most hydroxides EXCEPT sodium, potassium and ammonium hydroxides
Most oxides EXCEPT sodium, potassium and calcium oxides which react with water

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Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Science: Chemistry,
Science: Double Award
or Science: Single Award

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gcse examinations

chemistry

11984.02

THE PERIODIC TABLE OF ELEMENTS

Group

1	2											3	4	5	6	7	0
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La* Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac† Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

a
X
b

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

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