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General Certificate of Secondary Education
2025

Centre Number

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Candidate Number

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GCSE Chemistry

Unit 2

Higher Tier



[GCM22]

GCM22

FRIDAY 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 questions in black ink and use a dark HB pencil for drawings and graphs.

Do not write with a gel pen.

Answer all **six** 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.

You may use a scientific calculator.

Quality of written communication will be assessed in Question **3(c)**.

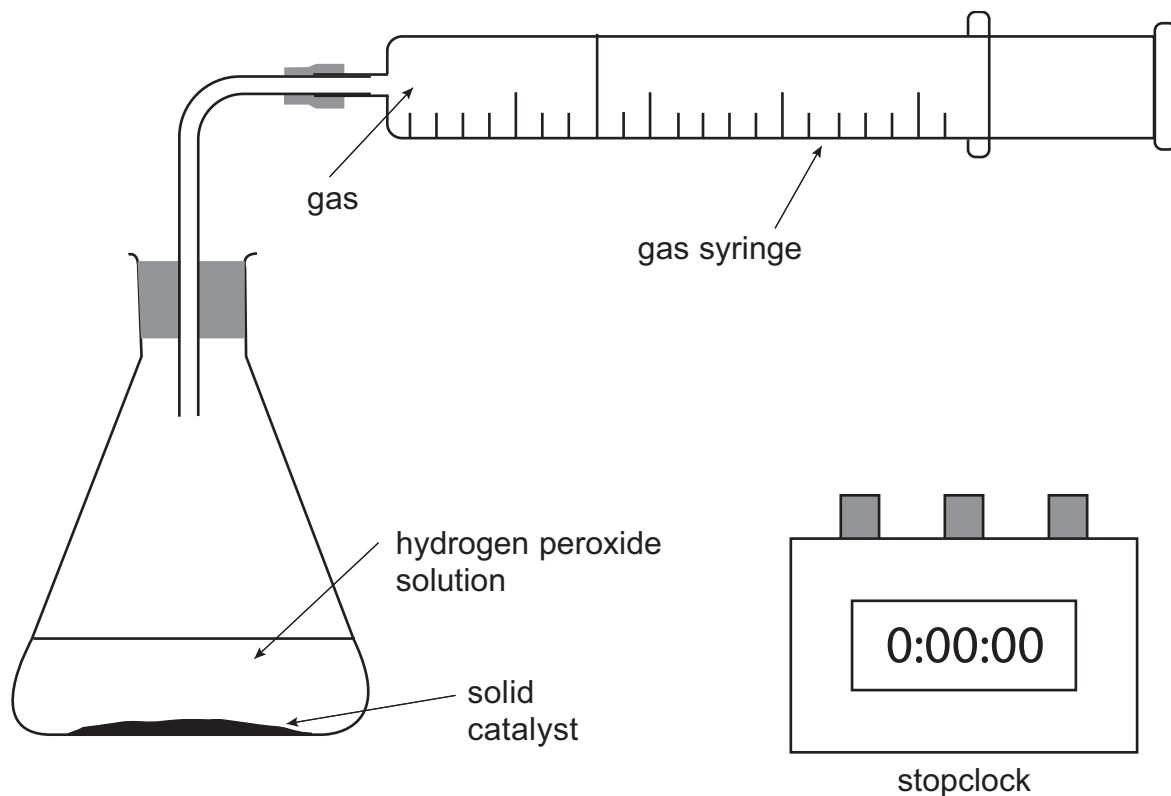
A Data Leaflet, which includes a Periodic Table of the Elements, is included in this question paper.

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24GCM2201

- 1 (a) An experiment was set up to investigate the effect of four different solid catalysts on the decomposition of hydrogen peroxide. A diagram of the apparatus used is shown below. 25.0 cm^3 of hydrogen peroxide solution and 1 g of solid catalyst were used in the reaction and the time taken to produce 100 cm^3 of gas was recorded.



Results of experiment

Solid catalyst	Time taken to collect 100 cm^3 of gas /s
A	120
B	35
C	11
D	54



(i) Name the products formed in the decomposition of hydrogen peroxide.

[1]

(ii) State and explain which solid (A, B, C or D) is the most effective catalyst.

[1]

(iii) Name one compound which could be used as a catalyst for the decomposition of hydrogen peroxide.

[1]

(iv) In the first experiment, 1 g of solid A was used. Describe how it could be shown experimentally at the end of the reaction that solid A was a catalyst and not a reactant.

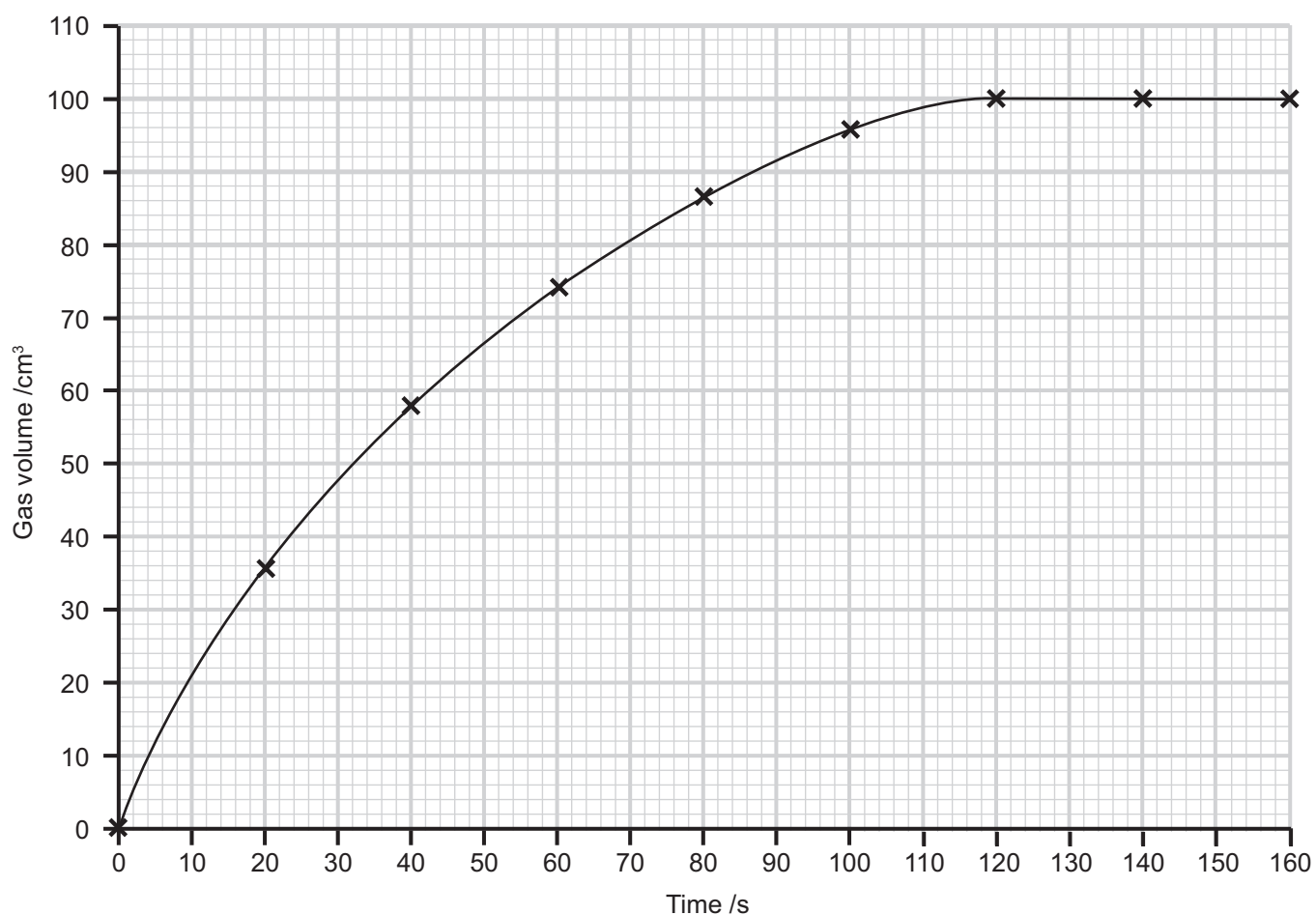
[3]

[Turn over



(b) The experiment was repeated using the same apparatus and the gas volume collected was recorded at intervals of 20 seconds. Catalyst A was used.

The graph shows the results obtained.



(i) What volume of gas was produced in the first 10 seconds?

_____ [1]

(ii) Describe fully how the gas volume produced changes with time.

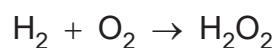
_____ [2]



- (iii) Explain, in terms of particles, why the rate of this reaction increases if the temperature of the hydrogen peroxide is increased and all other factors remain the same.

[3]

- (c) Hydrogen peroxide can be produced industrially from hydrogen and oxygen as shown in the equation below.



- (i) This reaction has a 100% atom economy. Explain how you can tell this from the equation.

[1]

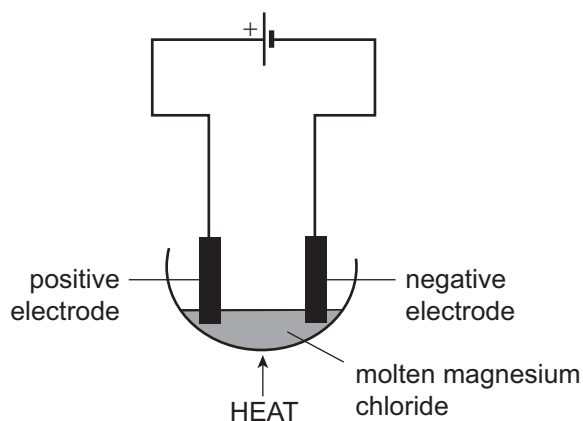
- (ii) Explain why industrial chemical processes should have as high an atom economy as possible.

[1]

[Turn over



- 2 Molten magnesium chloride undergoes electrolysis. The diagram below shows the apparatus which can be used to carry out this electrolysis. Molten magnesium is formed at the negative electrode and chlorine gas is formed at the positive electrode.



- (a) What is meant by the term electrolysis?

_____ [1]

- (b) Explain why molten magnesium chloride can undergo electrolysis.

_____ [1]

- (c) What is the name of the positive electrode?

_____ [1]

- (d) Write a half equation for the formation of chlorine gas at the positive electrode.

_____ [3]

- (e) What is observed at the positive electrode?

_____ [1]



(f) Magnesium is formed at the negative electrode. Explain how this process happens.

[2]

(g) The overall equation for the electrolysis of molten magnesium chloride is:



Calculate the volume of chlorine gas, in cm^3 , which is formed from the electrolysis of 0.38 g of magnesium chloride.

volume = _____ cm^3 [3]



3 The alcohols are a homologous series of organic compounds.

(a) The table below shows information about three different alcohols.

Alcohol	Melting point /°C	Boiling point /°C
CH ₃ OH	-94	65
C ₂ H ₅ OH	-118	78
C ₃ H ₇ OH	-129	97

(i) State two pieces of evidence from the table which show that the three alcohols belong to the same homologous series.

1. _____

2. _____

_____ [2]

(ii) Which alcohol(s) will be liquid at -100°C?

_____ [1]



(iii) There are two alcohols which have the molecular formula C_3H_7OH . Complete the table below by giving the structural formula and name of each alcohol.

	Structural formula	Name
1		
2		

[2]

(iv) Alcohols contain a functional group. What is meant by the term functional group?

A functional group is _____
_____ [1]

[Turn over



(b) Alcohols can be oxidised when exposed to air. Alcohols are often stored in glass bottles rather than bottles made of polymers such as PVC, since air cannot penetrate glass.

(i) Draw the structural formula and state the name of the organic product formed when CH_3OH is oxidised by air.

Structural formula

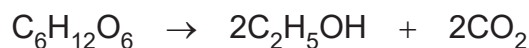
Name _____ [2]

(ii) Write an equation to show the formation of the polymer PVC.

[3]



- (d) The alcohol C_2H_5OH can be manufactured from glucose, $C_6H_{12}O_6$, by fermentation according to the following equation.



State the three conditions required for this fermentation reaction.

1. _____
2. _____
3. _____ [3]

- (e) The alcohol C_2H_5OH can also be manufactured by the reaction shown in the equation below.



- (i) Complete the equation above by inserting state symbols. [1]

- (ii) State the name of C_2H_4 . [1]
- _____

- (iii) Name the type of reaction shown in the equation above. [1]
- _____





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(Questions continue overleaf)

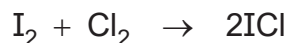
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- 4 An interhalogen compound contains two or more different halogen atoms and no atoms of any other elements. Iodine monochloride (ICl) is an interhalogen compound, formed when iodine reacts with chlorine as shown in the following equation.



- (a) Calculate the overall energy change for the reaction between iodine and chlorine to form iodine monochloride, using the bond energy values given below.
(Bond energies in kJ: I—I = 151; Cl—Cl = 242; I—Cl = 208)

Show your working out.

energy change = _____ kJ [4]

- (b) Circle the formula of one other interhalogen compound in the list below.

HCl Br₂ NaBr BrF₃ CCl₄

[1]

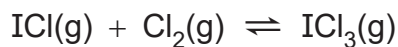
- (c) Iodine monochloride reacts with water to form hydrochloric acid, iodine, and iodic acid (HIO₃). Insert the two missing balancing numbers into the equation below for this reaction.



[1]



- (d) Iodine monochloride reacts in an exothermic reaction with more chlorine to form iodine trichloride (ICl₃). A dynamic equilibrium forms. Le Châtelier's Principle can be used to predict how the position of equilibrium changes if the conditions of the reaction are changed.



- (i) State two features of a dynamic equilibrium.

1. _____

2. _____

_____ [2]

- (ii) What is meant by the term exothermic?

_____ [1]

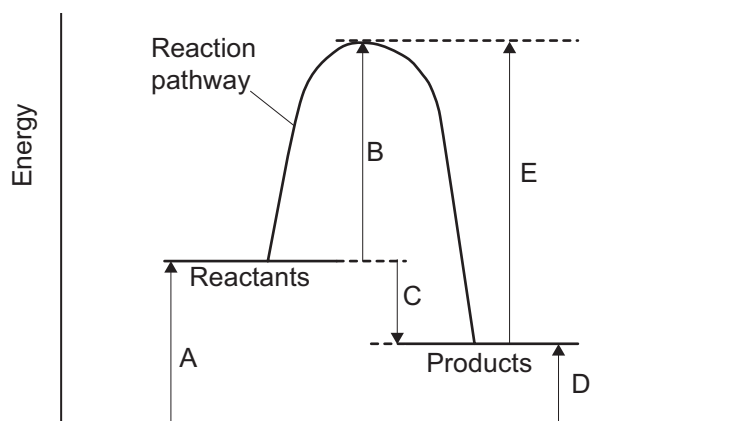
- (iii) State and explain how the yield of iodine trichloride would change if the pressure is increased.

_____ [3]

[Turn over



(e) The reaction profile for another reaction is shown below.



(i) State and explain if the reaction is exothermic or endothermic.

[1]

(ii) What label is missing from the x axis?

[1]

(iii) Select the letter (A, B, C, D or E) which represents the activation energy for the forward reaction.

[1]



5 Some metals, such as gold, can be found uncombined in nature.

(a) Suggest why gold metal is found uncombined in nature.

[1]

(b) Other metals such as aluminium, copper, zinc and iron are found combined with other elements in rocks called ores. These metals can be extracted from their ore by electrolysis or by chemical reduction.

(i) Cuprite is an ore of copper which contains copper(I) oxide. Copper(I) oxide contains the copper(I) ion, Cu^+ . Write the formula of copper(I) oxide.

[1]

(ii) Name the ore from which aluminium is extracted.

[1]

(iii) For each metal in the table below, select the correct method of extraction, electrolysis or chemical reduction. Place a tick (\checkmark) in one box in each row.

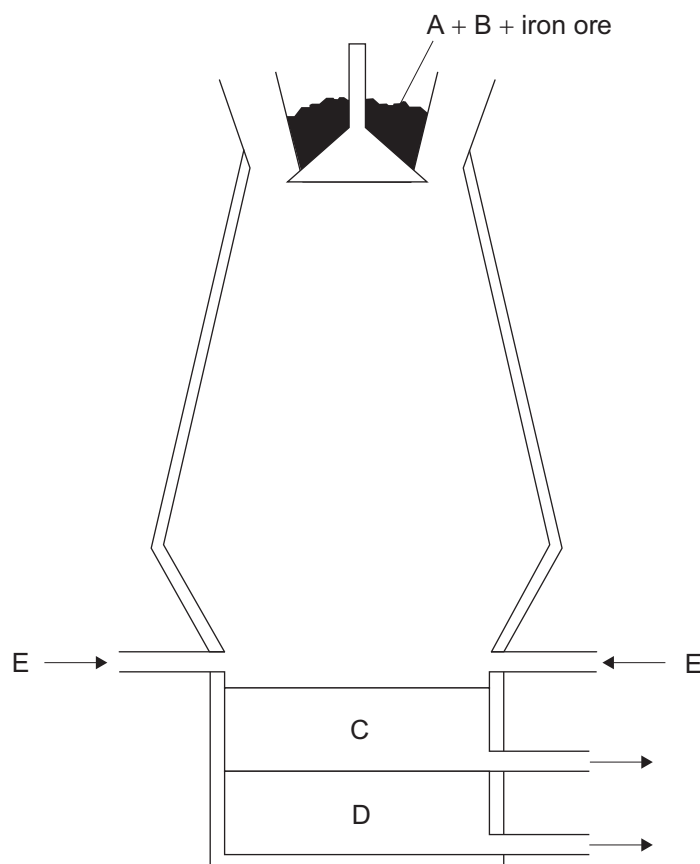
Metal	Electrolysis	Chemical reduction
Aluminium		
Copper		
Zinc		

[3]

[Turn over



(c) The diagram below shows a Blast Furnace used for the extraction of iron from iron ore.



(i) Raw material A is used to produce the reducing agent in the Blast Furnace. Name A and name the reducing agent.

A : _____

Reducing agent: _____ [2]

(ii) Describe how the reducing agent is produced in the Blast Furnace.

_____ [2]



(iii) What is the common name for iron ore?

_____ [1]

(iv) Write a balanced symbol equation for the reduction of iron ore in the Blast Furnace.

_____ [3]

(v) Name the raw material B added to the Blast Furnace to help remove the impurities from the iron ore.

_____ [1]

(vi) Identify C and E.

C: _____

E: _____ [2]

(d) Supplies of some metal ores are limited and only low-grade ores containing a small percentage of metal compounds remain. Copper can be extracted from these ores using phytomining. In this process a solution of copper(II) sulfate is produced and iron metal is added to extract the copper.

(i) Write a balanced symbol equation for the reaction of copper(II) sulfate with iron to produce copper and iron(II) sulfate.

_____ [2]

(ii) Write an ionic equation for the reaction of copper(II) sulfate with iron.

_____ [2]

(iii) Write a half equation for the reduction process in this reaction.

_____ [3]

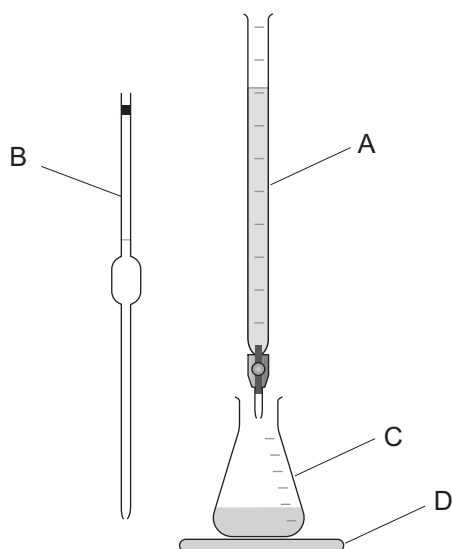
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- 6 Citric acid is found in many fruit juices. A titration was carried out to determine the concentration of a solution of citric acid.

25.0 cm³ of the citric acid solution were titrated against 2.0 g/dm³ sodium hydroxide solution. 33.0 cm³ of the sodium hydroxide solution were needed for neutralisation. The indicator used was phenolphthalein.

- (a) Some of the pieces of apparatus used in the titration are labelled A, B, C and D in the diagram below.



- (i) Name the pieces of apparatus labelled A, B, C and D.

A _____

B _____

C _____

D _____

[4]

- (ii) Apart from the apparatus above and a retort stand, boss and clamp, state one other essential piece of apparatus for the titration.

_____ [1]

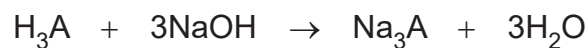
- (iii) State the colour change at the end point in this titration.

From _____ to _____

[2]



(b) The equation below shows the titration reaction. The citric acid is represented by H_3A .



(i) Calculate the number of moles of sodium hydroxide used in the titration.

moles of sodium hydroxide = _____ [2]

(ii) Calculate the number of moles of citric acid (H_3A) present in 25.0 cm^3 of solution.

moles of H_3A in 25.0 cm^3 = _____ [1]



(iii) Calculate the concentration of the citric acid solution in mol/dm^3 .

concentration = _____ mol/dm^3 [1]

(iv) Citric acid has a relative formula mass (M_r) of 192. Calculate the concentration of the citric acid solution in g/dm^3 .

concentration = _____ g/dm^3 [1]

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Question Number	Marks
1	
2	
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Total Marks	
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Examiner Number

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24GCM2224

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	$\text{C}_3\text{H}_7\text{COO}^-$
Carbonate	CO_3^{2-}
Dichromate	$\text{Cr}_2\text{O}_7^{2-}$
Ethanoate	CH_3COO^-
Hydrogencarbonate	HCO_3^-
Hydroxide	OH^-
Methanoate	HCOO^-
Nitrate	NO_3^-
Propanoate	$\text{C}_2\text{H}_5\text{COO}^-$
Sulfate	SO_4^{2-}
Sulfite	SO_3^{2-}



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

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

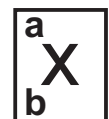
gcse examinations chemistry

THE PERIODIC TABLE OF ELEMENTS

Group

												1 H Hydrogen 1							4 He Helium 2
		1	2											3	4	5	6	7	0
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								

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



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

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