

Candidate Name

Candidate Number

Centre Name

Centre Number

Paper 2: Chemistry

For Examination December 2023

(2 hours)

It is necessary to respond on the answer sheets provided alongside this question paper. Additionally, you must have a soft pencil (preferably of type B or HB), a clean eraser and a dark blue or black pen.

INSTRUCTIONS:

- You must write your name, candidate number, centre name and centre number on the answer sheets in the designated spaces.
- Objective section consists of 25 questions, and it is essential that you attempt all of them.
- Each question has four options labelled A, B, C, and D. Select the option that you think is correct. Mark it on the multiple choice answer sheet using a soft pencil.
- Attempt all the questions from subjective section using a dark blue or black pen.
- It is important to follow the instructions provided on the answer sheets.
- Do not use correction fluid.
- Avoid writing on any bar codes.

INFORMATION:

- This paper has a total of 100 marks.
- In objective section there are 25 questions, each carries one mark. There is no negative marking for incorrect responses.
- In subjective section, 45 marks are for extended theory and 30 marks for practical component.
- The number of marks assigned for every question or its parts is indicated within brackets []

The Periodic Table of Elements

1	2	Key										3	4	5	6	7	0
1	2	relative atomic mass atomic symbol name atomic (proton) number										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	63.5 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	[97] 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	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[267] Rf rutherfordium 104	[270] Db dubnium 105	[269] Sg seaborgium 106	[270] Bh bohrium 107	[270] Hs hassium 108	[278] Mt meitnerium 109	[281] Ds darmstadtium 110	[281] Rg roentgenium 111	[285] Cn copernicium 112	[286] Nh nihonium 113	[289] Fl flerovium 114	[289] Mc moscovium 115	[293] Lv livermorium 116	[293] Ts tennessine 117	[294] Og oganeson 118

1 H hydrogen 1

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

* The Lanthanides (atomic numbers 58 – 71) and the Actinides (atomic numbers 90 – 103) have been omitted.

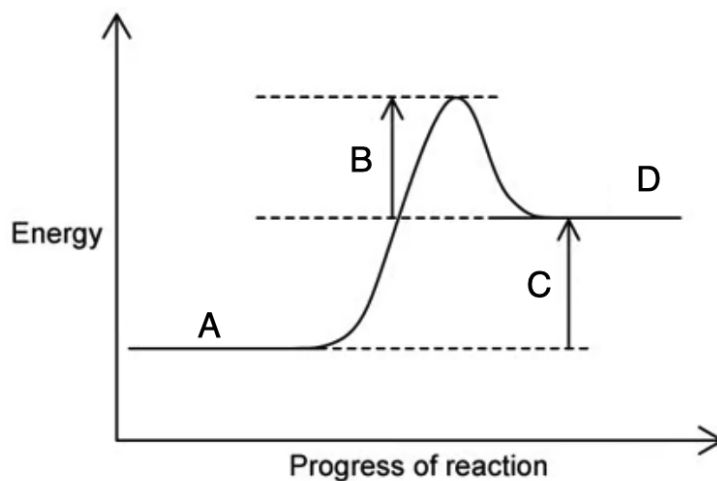
Relative atomic masses for Cu and Cl have not been rounded to the nearest whole number.

MCQ section 25 marks:

Q1) Which of the following reactions is endothermic?

- A: Reacting potassium to water
- B: Dissolving of Sodium chloride in water
- C: Burning fossil fuels
- D: Ice melting

Q2) Which letter correctly represents the enthalpy change of this reaction?



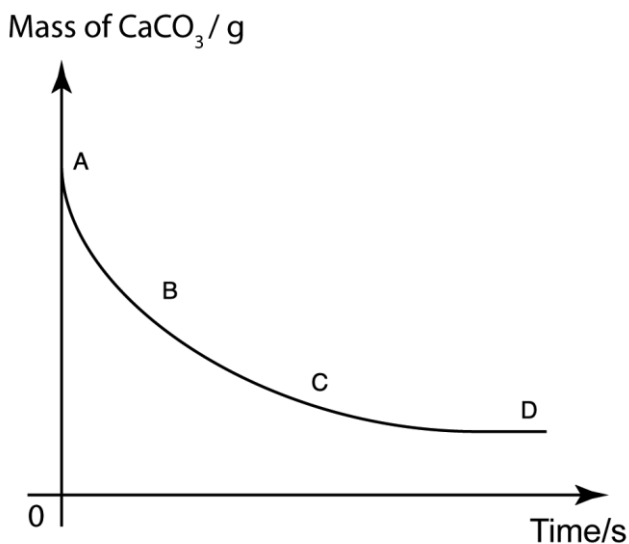
Q3) What is the role of light energy in a photochemical reaction?

- A: Disruption of chemical bonding
- B: Lower the activation energy
- C: Needed as a reactant
- D: Increase chemical reaction rate

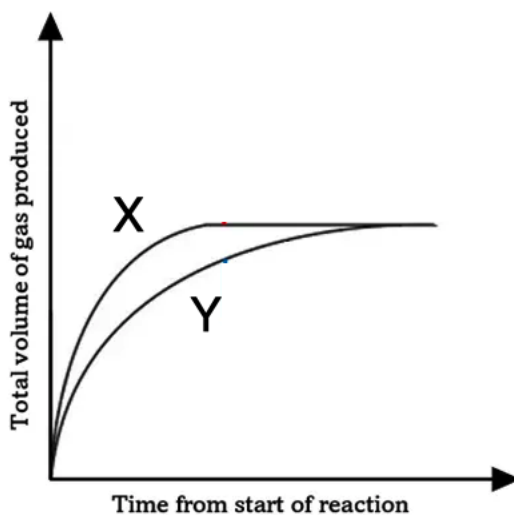
Q4) The rate of reaction between calcium carbonate and hydrochloric acid was investigated by using mass change over time.

At which point would be the slowest rate of reaction?

The results are plotted below:



Q5) The graph below shows the rate of reaction for the decomposition of a solution of hydrogen peroxide.



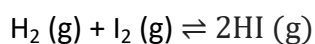
Which factor was increased that could lead to the observed results for X compared to Y?

- A: Volume
- B: pH
- C: Concentration
- D: Temperature

Q6) An unknown colourless liquid was discovered, using your knowledge of the chemical tests for water. Which row correctly describes the test and the colour changes involved for a positive result?

	Test	Initial colour	Final colour
A	Anhydrous copper sulphate	Blue	White
B	Cobalt chloride paper	Pink	Blue
C	Hydrous copper sulphate	White	Blue
D	Cobalt chloride paper	Blue	Pink

Q7) In the following reaction:



The forward reaction is endothermic, which of the following would have no effect on the equilibrium?

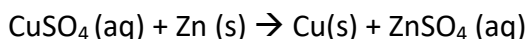
- A: Increase in pressure
- B: Decrease in reactants
- C: Increase the temperature
- D: Increase in products

Q8) Which combination of the statements correctly describes oxidation reactions:

1. Gain of electrons
2. Gain of oxygen
3. Gain of hydrogen
4. Loss of electrons
5. Loss of oxygen
6. Loss of hydrogen

- A: 1, 2 and 6
- B: 4, 5 and 6
- C: 2, 4, and 6
- D: 3, 4 and 5

Q9) Which of the following substances is the reducing agent?



- A: $\text{CuSO}_4 (\text{aq})$
- B: $\text{Zn} (\text{s})$
- C: $\text{Cu} (\text{s})$
- D: $\text{ZnSO}_4 (\text{aq})$

Q10) Both potassium manganate (VII) and potassium iodide can be used as a chemical test to test for reducing agents. Which row correctly describes the colour changes of both tests?

	Potassium manganate (VII) test	Potassium iodide test
A	colourless to purple/pink	colourless to orange/brown
B	purple/pink to colourless	orange/brown to colourless
C	colourless to purple/pink	orange/brown to colourless
D	pink/purple to colourless	colourless to orange/brown

Q11) Which element is involved in all the following for synthesizing proteins, chlorophyll, and nucleic acids in plants?

- A: Phosphorus
- B: Potassium
- C: Magnesium
- D: Nitrogen

Q12) Which substance is used as a common source of hydrogen used in the Haber process?

- A: Methane
- B: Air
- C: Hydrochloric acid
- D: Hydrogen peroxide

Q13) Sulphur is used in the rubber industry in a process called vulcanization. How does this process affect rubber?

- A: Enhancing colour
- B: Reduce viscosity
- C: Increased elasticity
- D: Increases hardness

Q14) Lime is used in a variety of different industries. Which of the following processes is used to manufacture lime?

- A: Thermal decomposition
- B: Neutralisation
- C: Polymerisation
- D: Distillation

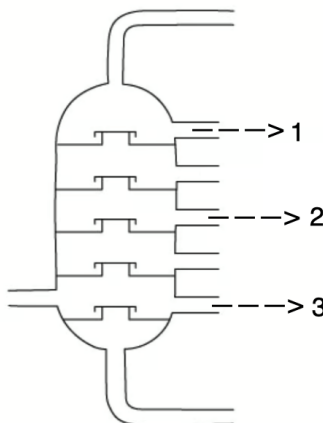
Q15) How do members of homologous series differ from one another?

- A: Different functional groups
- B: Different molecular formulas
- C: Different chemical properties
- D: Different physical states.

Q16) Identify the correct row which represents the correct alcohol with their molecular formula:

	Alcohol	Formula
A	Methanol	$\text{C}_2\text{H}_5\text{OH}$
B	Ethanol	CH_3OH
C	Butanol	$\text{C}_2\text{H}_5\text{OH}$
D	Propanol	$\text{C}_4\text{H}_{10}\text{OH}$

Q17) Which row correctly identifies the fractions from the fractional distillation of crude oil?



	1	2	3
A	Petrol	Diesel	Fuel oil
B	Bitumen	Petrol	Fuel oil
C	Kerosene	Diesel	Bitumen
D	Diesel	Petrol	Bitumen

Q18) Which one of the following is the final useful product of cracking?

- A: Ethylene
- B: Propylene
- C: Decane
- D: Octane

Q19) Which row correctly describes the type of bonds broken and the conditions needed for cracking of hydrocarbons?

	Type of Bond	Temperature	Catalyst
A	Ionic	450	Iron
B	Covalent	450	Silica
C	Covalent	600-700	Alumina
D	Ionic	600-700	Alumina

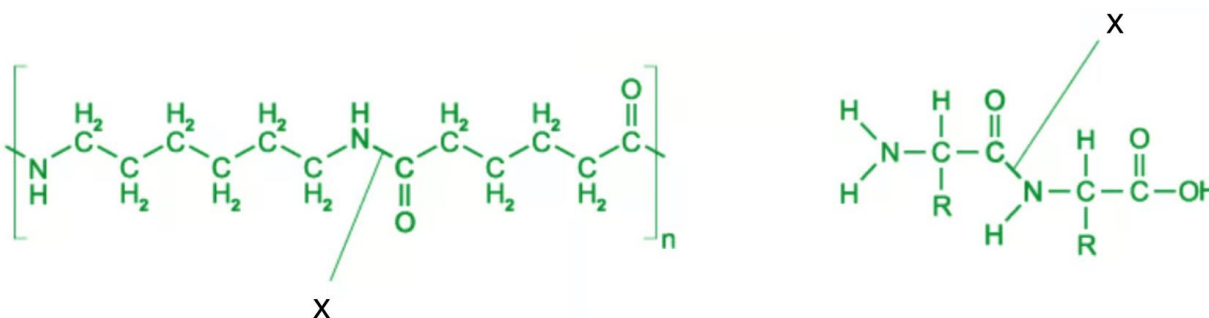
Q20) What is the role of bromine in bromine water when testing hydrocarbons?

- A: Oxidising agent
- B: Reducing agent
- C: Catalyst
- D: Indicator

Q21) Macromolecules can be made by joining smaller molecules called monomers together. This process is called polymerisation. Which row correctly describes monomers used to make polymers?

	Monomer	Polymer
A	ethane	poly(ethane)
B	ethene	poly(ethane)
C	ethene	poly(ethene)
D	ethane	poly(ethene)

Q22) Two polymers share the same type of bonding, using your knowledge identify the type of bond labelled X that joins these monomers together.



- A: Glycosidic
- B: Peptide
- C: Ester
- D: Carboxylic

Q23) Ethanol is an important chemical substance used in a variety of different industries. Correctly identify the balanced chemical equation for fermentation.

- A: $\text{C}_6\text{H}_{12}\text{O}_6 (\text{aq}) + \text{O}_2 (\text{g}) \longrightarrow 2\text{C}_2\text{H}_5\text{OH} (\text{aq}) + 2\text{CO}_2(\text{g})$
- B: $\text{C}_6\text{H}_{12}\text{O}_6 (\text{aq}) \longrightarrow 2\text{C}_2\text{H}_5\text{OH} (\text{aq}) + 2\text{CO}_2(\text{g})$
- C: $2\text{C}_2\text{H}_5\text{OH} (\text{aq}) + \text{O}_2 (\text{g}) \longrightarrow \text{C}_6\text{H}_{12}\text{O}_6 (\text{aq}) + 2\text{CO}_2(\text{g})$
- D: $2\text{C}_2\text{H}_5\text{OH} (\text{aq}) \longrightarrow \text{C}_6\text{H}_{12}\text{O}_6 (\text{aq}) + 2\text{CO}_2(\text{g})$

Q24) Which gas of the atmosphere had the largest change in percentage from early atmosphere to present day atmosphere composition?

- A: Carbon dioxide
- B: Oxygen
- C: Water vapour
- D: Nitrogen

Q25) Which one of the following is not a suitable strategy used to reduce acid rain?

- A: Flue gas desulphurization
- B: Catalytic converters
- C: Afforestation
- D: Switch to nuclear power

[Total 25 marks]

End of Multiple choice section [25 marks]

Part 2 Extended Theory: [45 marks]

- 1) The world's population has increased significantly over the last 50 years, and with it, there has been a substantial rise in the energy demand. Fossil fuels, including coal, oil, and natural gas, have historically been the dominant sources of energy globally.



- a) Explain how the pollutants released by the process of combustion of gas power station effect the environment. [6 marks]

[illegible]

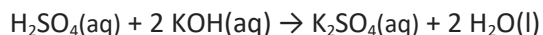
Another pollutant produced by burning coal involves the production of sulphur dioxide which can lead to acidic rain.

- b) Describe the consequences of acid rain. [4 marks]

[illegible]

A sample of water was collected from rainwater nearby a coal power station to determine the concentration of sulphuric acid caused by the pollutants produced by burning coal. The students carried out a titration to deduce the concentration of sulphuric acid.

The equation for this chemical reaction for this reaction:



H = 1, S = 32, K = 39, O = 16,

Assuming no other contaminants were present in the rainwater, 25cm³ of rainwater containing sulphuric acid was placed in a conical flask. Slowly adding potassium hydroxide with a concentration of 0.500 mol/dm³, it took a total of 17.5cm³ to completely react with the sample to the point of neutralisation.

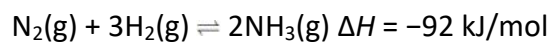
Calculate the concentration of the acid in both mol/dm³ and g/dm³. [5 marks]

Show your wording in the space below:

Concentration in mol/dm³ _____
Concentration in g/dm³ _____

[Total 15 marks]

2) The Haber process is used to make ammonia; the chemical reaction is below:



a) What is meant by the symbol \rightleftharpoons ? [1 mark]

b) Describe the process by which nitrogen is separated from the air. [1 mark]

c) Complete the table to describe the conditions used in the Haber process: [3 marks]

Conditions	Values
Temperature $^{\circ}\text{C}$	
Pressure (atm)	
Catalyst used	

d) The Haber process forward reaction is exothermic.

Evaluate the effect using a higher temperature ammonia production. [6 marks]

- e) Assuming all nitrogen and hydrogen available was converted into ammonia. What mass of nitrogen and hydrogen could be needed to produce 51kg of ammonia. [3 marks]

Show your working:

N = 14 and H = 1

Mass of Nitrogen _____ kg

Mass of Hydrogen _____ kg

- f) Only about 15% of the nitrogen available is converted into ammonia. Deduce the actual mass of Nitrogen needed to produce 51kg of ammonia? [2 marks]

Mass of nitrogen needed: _____

- g) Deduce the volume in dm^3 this mass of nitrogen will occupy? [2 marks]

Volume _____ dm^3

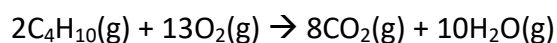
[Total 18]

4) Butane can be used in hand held blow torches.



The combustion reaction between butane and oxygen is exothermic.

The chemical equation for complete combustion:

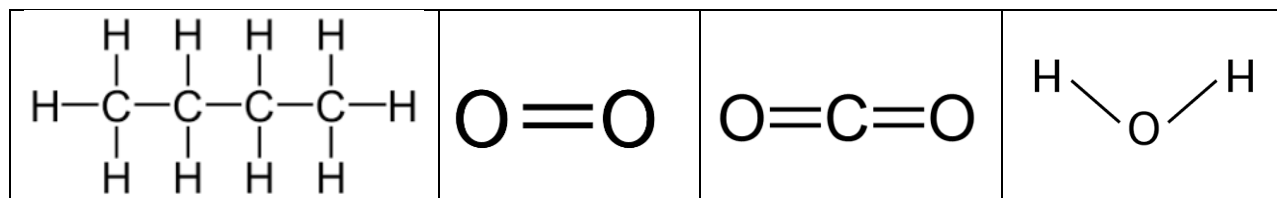
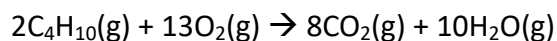


a) Butane is a hydrocarbon, explain what is meant by the term hydrocarbon? [1 mark]

b) Describe the conditions needed for incomplete combustion to occur and explain why it is dangerous? [3 marks]

Question 4 is continued on the next page.

The table below shows some of the bond energies combustion of butane:



Bond	C-H	C-C	O=O	C=O	H-O
Energy in kJ/mol	413	348	495	802	463

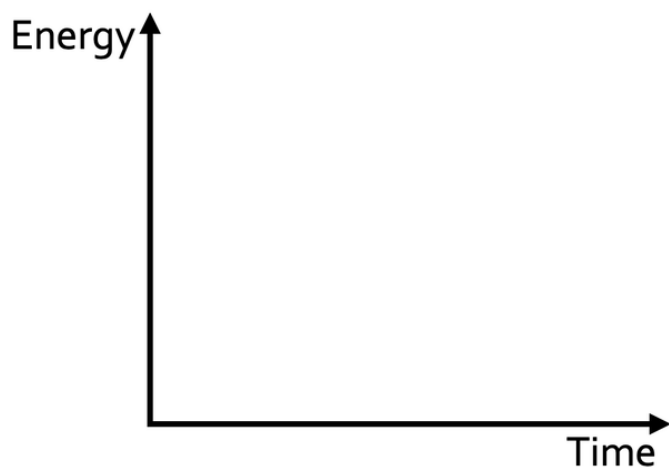
c) Using the balanced chemical equation calculate the energy change for the combustion of butane? [4 marks]

Show your working:

Enthalpy change: _____ kJ/mol

d) Sketch energy reaction profile for the combustion of butane? [3]

Include appropriate labelling.



e) Explain in terms of the energy involved in bond breaking and bond making why this reaction is exothermic? [2 marks]

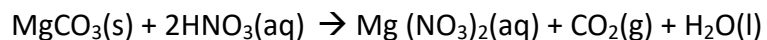
[Total 12 marks]

End of Extended theory [45 marks]

Part 3: Practical component:

Q1) Magnesium carbonate reacts with concentrated nitric acid. This reaction is exothermic.

The chemical equation for this equation is:



a) Write the ionic equation for this reaction. [2 marks]

b) Plan an investigation to investigate the effect of surface area on the temperature changes of this reaction. [6 marks]

- Include details of equipment used.

[Total 8 marks]

- 2) A student investigated the rate of reaction between a solution of sodium thiosulfate and dilute hydrochloric acid. The student set the experiment as in the image below:

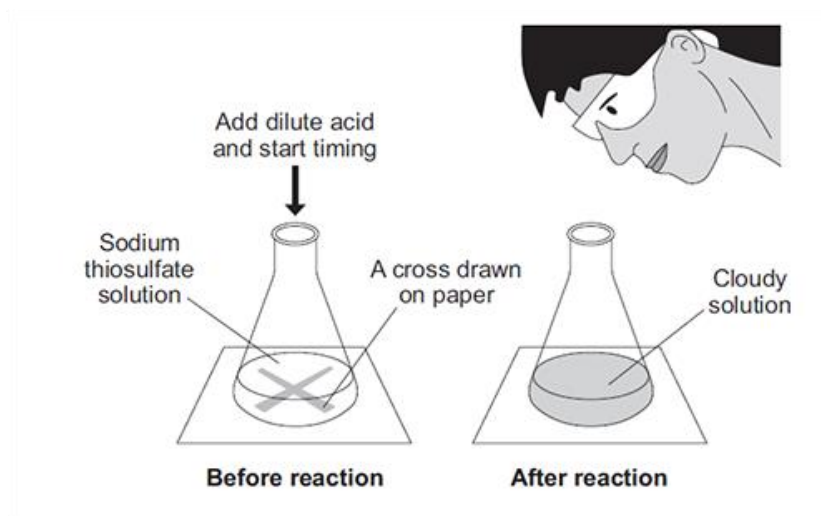


Figure 1

Both solutions initially are colourless, upon addition of the two solutions together the solution turns cloudy. The chemical reaction is:



- a) What is the purpose of the X on the paper? [1 mark]

- b) Explain why the solution changes to a cloudy pale yellow colour. [2 marks]

The students decided to investigate the effect of concentration on the time it took for the solution to turn cloudy. The results are below:

Concentration of sodium thiosulfate solution in mol/dm ³	Time in seconds
0.1	85
0.2	43
0.3	21
0.4	15
0.5	10

Table 1

c) Correctly identify the following variables: [3 marks]

Independent variable:

Dependent variable:

State two control variables:

d) Describe and explain the relationship between the concentration of sodium thiosulfate solution and the time taken? [4 marks]

- e) Describe improvements that could be done to improve the validity of this experiment using both **Figure 1** and **Table 1** to assist you. [4 marks]

[Total 14 marks]

Q3) Water pollution is a major concern, particularly in countries that do not have access to potable water.



a) Define the term potable water. [1 mark]

b) Describe a suitable method to determine the mass of dissolved solids in 100cm^3 of river water. [3 marks]

Natural disasters or poorly maintained infrastructure may lead to raw sewage entering wastewater. Raw sewage contains organic matter.

c) Describe how sewage is treated to remove organic matter. [4 marks]

[Total 8 marks]

End of Practical component [30 marks]