Name:	Class:	Class Register Number:

中正中学

CHUNG CHENG HIGH SCHOOL (MAIN)

Parent's Signature

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PRELIMINARY EXAMINATION 2022
SECONDARY 4

CHEMISTRY **6092/02**

Paper 2 **12 September 2022**
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number clearly in the spaces provided at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 24.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Section A	/ 50
Section B	
B6	/ 12
B7	/ 8
B8 ( )	/ 10
Total	/ 80

This document consists of **24** printed pages.

[Turn over

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The formulae of some gases are given in the following list.

NH_3	O_2	CO	Cl_2	He
CO_2	SO_2	NO	H_2	CH_4

Choose formulae from above to answer the following questions.

You may use each formula once, more than once or not at all.

(a) Give the formulae of **two** gases which are elements.

.....[1]

(b) Give the formulae of **two** gases that will change the colour of a damp red litmus paper.

..... and .....[1]

(c) Give the formulae of **two** gases that are involved in both respiration and photosynthesis.

..... and .....[1]

(d) Give the formula of a gas that contains an element with an oxidation state of –4.

.....[1]

(e) Give the formula of a gas which is oxidised in the catalytic convertor.

.....[

[Total:

A2 The table shows some information about the atoms of elements **A**, **B**, **C**, **D**, **E** and **F**.
(The letters do not represent the atomic symbols of the elements.)

element	number of protons	number of neutrons	nucleon number
A	8	6	14
B	7	7	14
C	37		85
D	19	20	39
E	8	9	17
F	26	30	

(a) *(i)* Fill in the blanks in the table above. [1]

(ii) Write the electronic configuration of element **D**.

.....[1]

(iii) **E** can form a stable ion.
Write the formula of this ion.

.....[1]

(iv) Identify the isotopes of the same element from the table. Explain your answer.

.....

.....[1]

(b) *(i)* Use the information in the table to identify the elements **B**, **D** and **F**.

B: .....

D: .....

F: .....

[1]

(ii) State the trend in the melting point of the elements **B**, **D** and **F**.

Highest melting point .....

.....

Lowest melting point .....

[1]

(iii) Explain your reasoning for the difference in melting points for **B** and **F**.

.....

.....

.....

.....[2]

(c) **B** and **C** can react to form a compound.

Draw a dot-and-cross diagram to show the bonding in this compound.

Show outer shell electrons only.

[

[Total: 1

A3 The Winkler Method can be used to determine the oxygen concentration in water samples. The reactions involved are:

Step 1: Manganese(II) sulfate is added to an excess of alkali.

$$MnSO_4\,(aq) + 2KOH\,(aq) \longrightarrow Mn(OH)_2\,(s) + K_2SO_4\,(aq)$$

Step 2: The resulting mixture above is added to 100 cm^3 of water containing dissolved oxygen.

$$2H_2O\,(l) + 4Mn(OH)_2\,(s) + O_2\,(aq) \longrightarrow 4Mn(OH)_3\,(s)$$

Step 3: An excess of acidified potassium iodide is then added.

$$2Mn(OH)_3(s) + 2KI(aq) + 3H_2SO_4(aq) \longrightarrow 2MnSO_4(aq) + K_2SO_4(aq) + I_2(aq) + 6H_2O(l)$$

Step 4: The mixture is then transferred to a conical flask and titrated with a standard solution of sodium thiosulfate using starch as an indicator.

$$I_2\,(aq) + 2Na_2S_2O_3\,(aq) \longrightarrow 2NaI\,(aq) + Na_2S_4O_6\,(aq)$$
colourless — colourless

(a) State two observations where manganese shows the typical characteristics of a transition element during these reactions.

.....

.....

.....[2]

(b) Write the ionic equation for step 3.

.....[1]

(c) Sulfur can exhibit two oxidation states.

Table 3.1

	oxidation state of sulfur
$Na_2S_2O_3$	
$Na_2S_4O_6$	+2.5

(i) Fill in the missing oxidation state of sulfur in Table 3.1. [1]

(ii) Use oxidation states to show why step 4 is a redox reaction.

.....

.....

.....[2]

[Turn over

(d) State the colour change of the end point in step 4

.....[1]

(e) A 100 cm^3 sample of water containing dissolved oxygen required 11.20 cm^3 of 0.0100 mol/dm^3 sodium thiosulfate solution to reach the end point.

Calculate the concentration of oxygen in this sample of water in mol/dm^3.

[3]

[Total: 10]

A4 Methane, methanol and hydrogen have been investigated as possible alternative fuels for motor vehicles that currently use petrol. The table below compares the energy released on combustion of these fuels.

The enthalpy change of combustion of a substance, ΔH_c, is defined as the energy released when one mole of the substance is completely burnt in oxygen.

fuel	density / g/dm³	ΔH_c / kJ/mol	energy per gram / kJ/g
petrol	710 – 770	–	47.3
methane	*to be calculated*	–891	55.7
methanol	792	–726	*to be calculated*
hydrogen	0.0884	–286	143

(a) **(i)** Calculate the density for methane in g/dm³.

.....[1]

(ii) Calculate the energy per gram for methanol in kJ/g.

.....[1]

(iii) Suggest why no value is quoted for the enthalpy change of combustion of petrol in the table above.

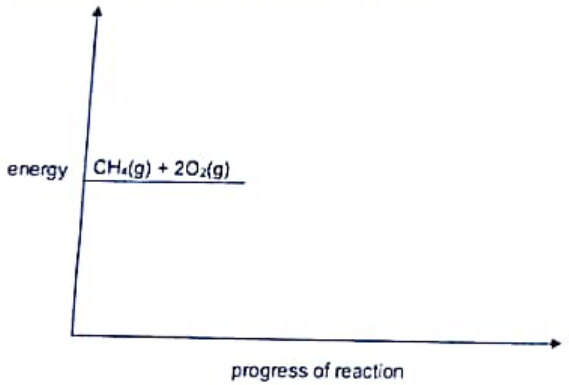
.....

.....[1]

(b) Methane and methanol undergo complete combustion to give the same products.

(i) Draw an energy profile diagram to show when methane is completely burnt in oxygen.

Your diagram should show and label the chemical formulae of the products, the activation energy and enthalpy change of reaction.



[3]

[Turn over

(ii) Which fuel, methane or methanol, is likely to give sootier exhaust products when it is combusted in the same volume of air in the motor vehicle engine? Explain your answer.

.....

.....

.....[2]

(c) Although hydrogen releases less than half the energy than methane per mole, many people believe that hydrogen is a better alternative fuel compared to methane. Suggest why this is so.

.....

.....[2]

(d) One alternative fuel technology involves the conversion of liquid methanol into hydrogen gas as shown by the equations below. The hydrogen obtained can then be used as a fuel.

step 1: $CH_3OH(l) \longrightarrow CH_3OH(g)$

step 2: $CH_3OH(g) \longrightarrow 2H_2(g) + CO(g)$

(i) Use the given information below to calculate the enthalpy change of reaction for **step 2** in kJ/mol.

	Bond energy in kJ/mol
C–H	410
C–O	360
C≡O in CO (g)	1077
O–H	463
H–H	436

[2]

(ii) Explain why the enthalpy change for the conversion of liquid methanol to hydrogen is greater in magnitude than that for the conversion of gaseous methanol to hydrogen.

.....

.....[1]

(iii) Suggest why this alternative fuel technology to produce hydrogen is sometimes said to have a harmful effect.

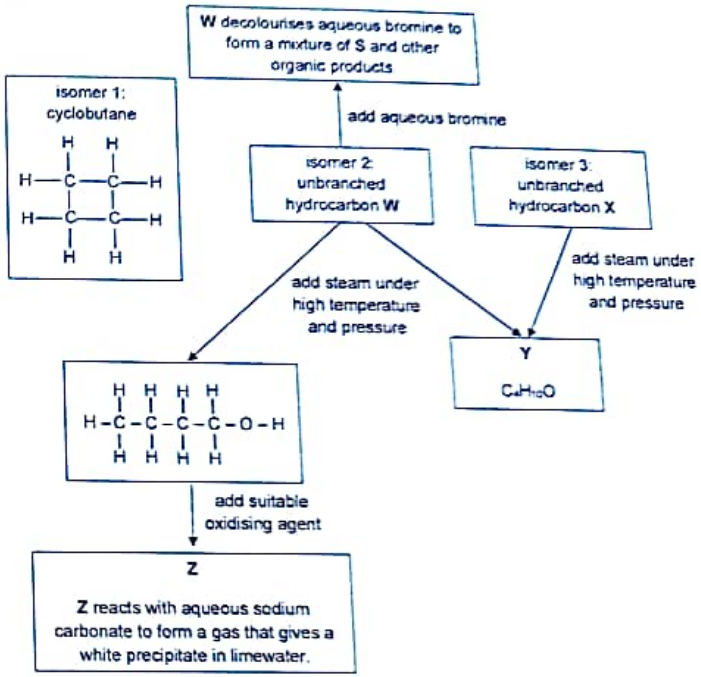
.....

.....[1]

[Total: 14]

A5 In some oil refineries, naphtha is heated to form a mixture of hydrocarbons.

Some of these hydrocarbons are isomers. Some information about the isomers 1, 2 and 3 is shown below.



(a) Isomer 1 belongs to a homologous series called cycloalkane.

(i) The next member in the homologous series of isomer 1 has a higher boiling point. State the molecular formula of this member.

.....[1]

(ii) Cyclobutane has the same chemical reactivity as butane.

When excess cyclobutane reacts with chlorine, a chlorine-containing organic compound is formed.

State the condition and write a balanced equation to show how this chlorine-containing organic compound can be formed.

.....

.....[2]

(b) (i) State the molecular formula of **W**.

.....[1]

(ii) Use the information in the reaction scheme to deduce and draw the full structural formulae of the organic compounds **W**, **X**, **Y** and **Z**.

organic compound	structural formula
W	
X	
Y	
Z	

[4]

(c) **S** is an organic compound that has the following composition by mass:

H 5.9%; O 10.5%; Br 52.3%

Calculate the empirical formula of **S**.

Show your working clearly.

empirical formula .....

[3]

[Total: 11]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B5 Read the information about the relationships between the electronegativity of elements, chemical bonding between elements and their bond energies.

Electronegativity of elements

Electronegativity is a measurement of the tendency of an atom to attract a bonding pair of electrons. A bonding pair of electrons is the pair of electrons shared in a chemical bond.

The Pauling scale is used to measure the electronegativity of elements. It ranges from 0.7 to 4.0, with a higher value representing greater electronegativity. The greater the electronegativity of an atom, the greater the tendency for the atom to attract the bonding pair of electrons to itself in a chemical bond.

The values of the electronegativity of the first twenty elements in the Periodic Table are given in Table 6.1. The electronegativity value of sodium has been intentionally left out.

Table 6.1

element	electronegativity
H	2.20
He	No data
Li	0.98
Be	1.57
B	2.04
C	2.55
N	3.04
O	3.44
F	3.98
Ne	no data
Na	
Mg	1.31
Al	1.61
Si	1.90
P	2.19
S	2.58
Cl	3.16
Ar	no data
K	0.82
Ca	1.00

The difference in electronegativity between two elements involved in a chemical bond, Σ, can be calculated by subtracting the smaller electronegativity value from the larger electronegativity value.

Σ gives a good indication of whether a chemical bond formed between two elements is ionic or **covalent**. The general rule states that if a chemical bond is an ionic bond, the Σ value is greater than 2.0. An example is magnesium fluoride, MgF_2, where Σ = 3.98 – 1.31 = 2.67.

However, there are exceptions to this rule.

Elements and their oxides and chlorides

The formulae and chemical bonding of the oxides and chlorides of some elements are given in Table 6.2. The bonding in aluminium oxide has been intentionally left out.

Table 6.2

element	formula of main oxide	bonding in oxide	formula of main chloride	bonding in chloride
H	H_2O	covalent	HCl	covalent
Mg	MgO	ionic	$MgCl_2$	ionic
Al	Al_2O_3		$AlCl_3$	covalent
P	P_4O_{10}	covalent	PCl_5	covalent
S	SO_2	covalent	S_2Cl_2	covalent

Bond energies

Bond energies give an indication of the strength of the covalent bond. The higher the bond energy, the stronger the covalent bond.

The bond energies of some covalent bonds are given in Table 6.3.

Table 6.3

covalent bond	bond energy / kJ/mol	covalent bond	bond energy / kJ/mol
H – H	432	O = O	494
H – F	562	C ≡ O	1077
H – Cl	431	C = O	799
P – Cl	346	C – O	358

(a) (i) Describe and explain the trend in the electronegativity of Group II element.

.....

.....

.....[2]

(ii) Predict the electronegativity of sodium.

.....[1]

(b) In Table 6.1, the electronegativity of helium, neon and argon are noted as 'no data'. Suggest why this is so.

.....

.....[2]

(c) Aluminium oxide and aluminium chloride melt at 2072 °C and 192 °C respectively.

Calculate the electronegativity differences, Σ values for aluminium oxide **and** aluminium chloride.

Do the Σ values support the bonding in aluminium oxide **and** aluminium chloride?

Explain your answer.

.....

.....[2]

(d) Two students talk about the information given.

Student 1: 'I think that the electronegativity difference, Σ value, is directly proportional to the bond energy of a single covalent bond between two different atoms.'

Student 2: 'I think that the electronegativity difference, Σ value, can predict the covalent bond strength.'

Does the information in the tables support the ideas of the students?

Student 1:

.....

.....

.....

Student 2:

.....

.....

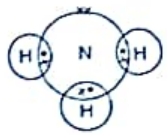
.....

[2]

[Turn over

(e) Diagrams can be used to represent how particles are chemically bonded.

(i) The 'dot-and-cross' diagram of an ammonia molecule is shown below.



Based on your understanding of electronegativity, suggest why the 'dot-and-cross' diagram is not an accurate representation of the covalent bonds in ammonia.

.....

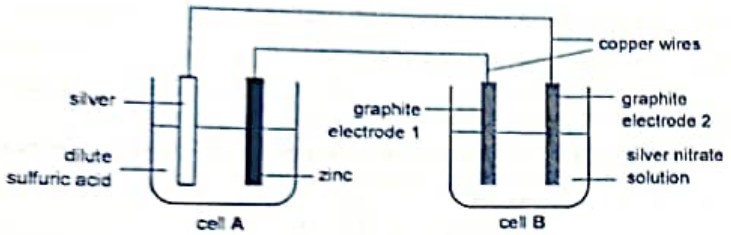
.....[1]

(ii) Draw a 'dot-and-cross' diagram for S_2Cl_2.

[2]

[Total: 12]

B7 An electrolytic and electrochemical set-up consisting of two cells are shown in the diagram below.



(a) Both cell **A** and cell **B** use electrodes, electrolytes and copper wires for electrical conduction.

Describe how the electrodes, electrolytes and copper wires conduct electricity.

.....

.....[2]

(b) In cell **A**, zinc is the negative electrode.

Write the overall equation for the reaction in cell **A**.

.....[1]

(c) ***(i)*** Write an ionic equation for the reaction at the graphite electrode **1** in cell **B**.

.....[1]

(ii) Describe and explain the change in pH, if any, of the electrolyte in cell **B**.

.....

.....

.....[2]

(d) The electrolyte in cell **B** is replaced with molten aluminium oxide.

After a long period of time, one of the graphite electrodes in cell **B** reduces in size and needs to be replaced.

Explain why this graphite electrode needs to be replaced.

.....

.....[2]

[Total: 8]

EITHER

B8 The table below compares the time taken for an alloy to react with ethanoic acid, nitric acid and phosphoric acid, each at three different concentrations. The time taken for the alloy to decrease in mass by 1.0 g was measured. All other conditions were kept the same.

acid	time taken for reaction / hours		
	concentration of acid 0.04 mol/dm^3	concentration of acid 0.02 mol/dm^3	concentration of acid 0.01 mol/dm^3
ethanoic acid	92	190	410
nitric acid	2	6	18
phosphoric acid	19	39	80

(a) **(i)** Explain, in terms of reacting particles, the difference in rate of reaction when the alloy reacts with 0.02 mol/dm^3 nitric acid and 0.02 mol/dm^3 phosphoric acid separately.

.....

.....

.....[2]

(ii) Hydrochloric acid can also react with the alloy.

Estimate the time taken for 0.01 mol/dm^3 hydrochloric acid to react with the alloy.

.....[1]

(b) Ethanoic acid is added to an alloy that consists of magnesium and copper.

(i) Write an equation to show how ethanoic acid reacts with the alloy.

.....[1]

(ii) Describe how pure copper can be obtained from the alloy by using ethanoic acid.

.....

.....

.....[2]

[Turn over

(c) Ethanoic acid can react with thionyl chloride to form ethanoyl chloride CH_3COCl as shown below.

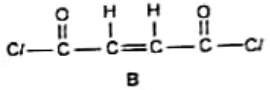
$$CH_3COOH + SOCl_2 \rightarrow CH_3COCl + HCl + \text{acidic gas A}$$

(i) Describe a chemical test to identify the acidic gas A.

.....

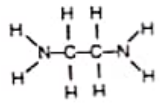
.....[2]

(ii) Another organic compound B, that contains the same functional group as ethanoyl chloride, is shown below.



B

Under suitable conditions, organic compound B can undergo condensation polymerisation with another organic compound C to form a polymer.



C

Draw one repeating unit to show the structure of this polymer.

[2]

[Total: 10]

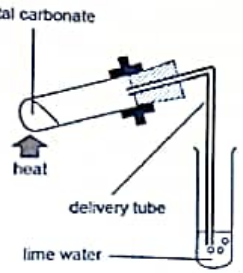
OR

B8 Elements in the Periodic Table have different reactivity.

In this question, the reactivities of some metal compounds and halogens are investigated.

(a) The thermal decomposition of three solid anhydrous metal carbonates, XCO_3, YCO_3 and ZCO_3 was investigated.

A pure 1.0 g sample of each carbonate was separately heated using the set-up shown below.



Appropriate mass measurements were made, and the following observations were noted during the experiment.

metal carbonate	observations
XCO_3	White solid remains white. White precipitate observed with limewater after some time.
YCO_3	White solid remains white No precipitate observed with limewater.
ZCO_3	White solid turns orange-brown then black almost immediately. White precipitate observed in limewater almost immediately.

(i) Write a balanced equation for the formation of the white precipitate.

.....[1]

(ii) Deduce the order of reactivity of metals **X**, **Y** and **Z** using the information above. Explain your reasoning.

....., ..., ...
most reactive least reactive

.....

.....

.....[3]

(b) Bromine reacts with phosphorus.

$$2P + 3Br_2 \rightleftharpoons 2PBr_3$$

(i) In practice, when phosphorus reacts with bromine, the yield of phosphorus tribromide is never 100%.

Suggest a reason why.

.....

.....[1]

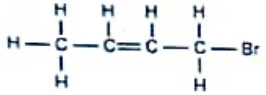
(ii) When the same number of moles of phosphorus is reacted with both bromine and chlorine, the rates for the two reactions are different.

State and explain the difference in the rate of both reactions.

.....

.....[2]

(c) Bromine can react with a hydrocarbon in a series of reaction to form an organic compound with the structure shown below.



This organic compound can undergo addition polymerisation to form a polymer.

(i) Draw the structure of this polymer showing two repeating units.

[1]

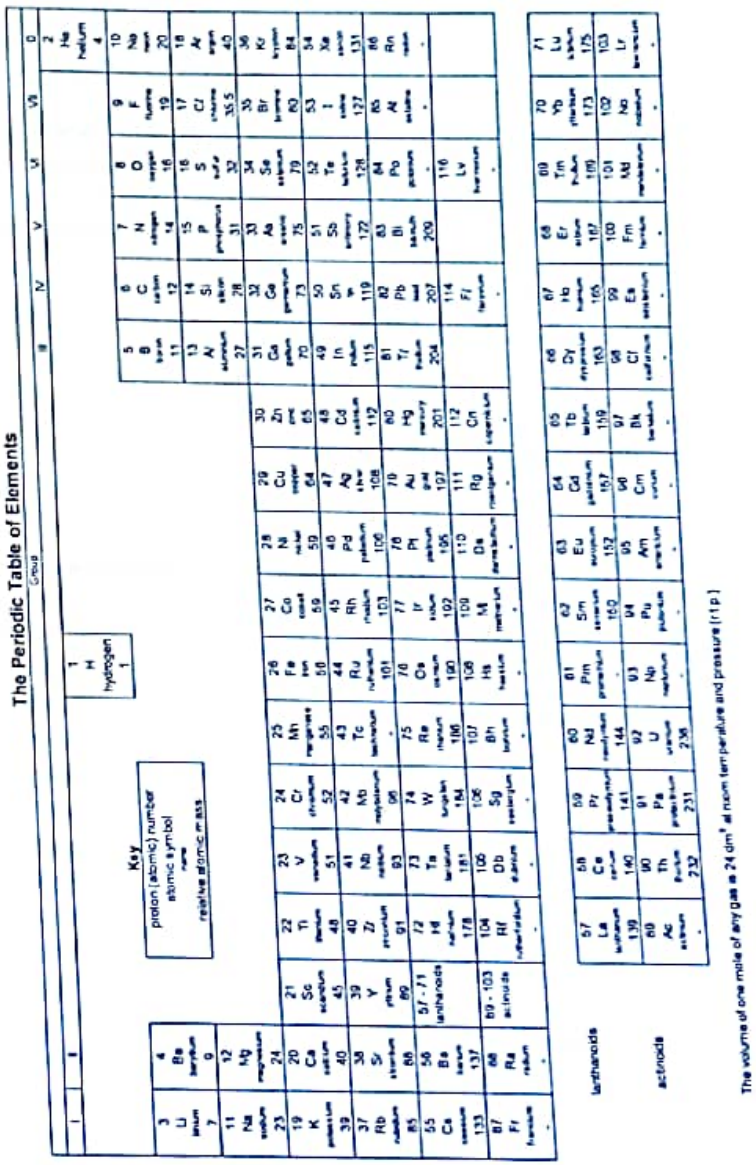
(ii) A sample of the polymer was analysed and found to have an average relative molecular mass of 33750.

Calculate the number of carbon atoms present in an average chain.

[2]

[Total: 10]

The Periodic Table of Elements



The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.)