Class/ Index Number	'O' Level Index Number	Name
/	/	

新加坡海星中学

MARIS STELLA HIGH SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR

CHEMISTRY **6092/02**
Paper 2 **23 August 2023**
1 hour 45 minutes

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST
Write your class, index number, Centre number, O level index number and name in the spaces 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.

This is Section A of the paper.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper (sections A and B) is 80.
A copy of the Periodic Table is printed on page 10.

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

At the end of the examination, hand in the following separately:
(1) Section A
(2) Section B

For Examiner's Use	
Section A	50
Section B	30
Total	80

This document consists of 10 printed pages.

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

A1 The table below shows a list of organic substances.

letters representing the substance	substance
A	C_3H_8
B	C_3H_6
C	CF_2Cl_2
D	C_2H_5COOH
E	poly(propene)
F	butyl methanoate
G	terylene
H	propanol

(a) You may use the letters once, more than once or not at all to answer the following questions.

(i) Which two substances have the same empirical formula?

..... **[1]**

(ii) Which substance increases our exposure to ultra-violet radiation from the sun?

..... **[1]**

(iii) Which substance can react with magnesium carbonate to form a salt?

..... **[1]**

(iv) Which substance is formed when substance B undergoes hydration?

..... **[1]**

(b) Describe a chemical test to differentiate substances A and B. Indicate the results of the test for both substances A and B.

.....

.....

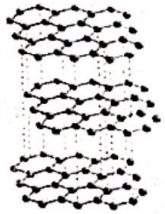
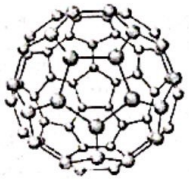
.....

.....

..... **[3]**

[Total: 7]

A2 Three allotropes of carbon are given.

allotropes	melting point (°C)
diamond 	4000
graphite 	3600 (sublimes)
fullerene (C_{60}) 	280

(a) State one physical property that is common for all three carbon allotropes.

..... [1]

(b) State one physical property of graphite that is different from diamond. Explain why graphite have this physical property based on its structure.

.....

.....

.....

.....

..... [3]

(c) State the change in movement of the particles of fullerene at 280 °C.

..... [1]

(d) Explain, using your knowledge on structures and properties, why fullerene has a low melting point.

.....

.....

..... [2]

[Total: 7]

A3 The table shows the bond strength of some hydrogen-halogen bonds.

hydrogen halide	bond strength (kJ/mol)
H-F	571
H-Cl	432
H-Br	366
H-I	298

(a) Describe the relationship between the reactivity of the halogens and the bond strength of the hydrogen halides.

.....

..... [1]

(b) Explain which hydrogen halide forms a stronger acid, HCl or HI, when dissociated in water.

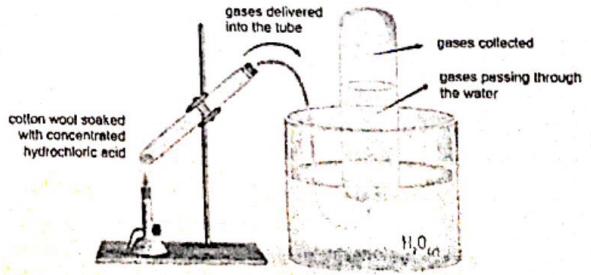
.....

.....

..... [2]

(c) Hydrogen chloride gas (HCl) can be decomposed using the set-up to form hydrogen gas and chlorine gas:

$$2HCl\,(g) \rightarrow H_2\,(g) + Cl_2\,(g)$$



(i) Which gas is delivered into the tube first, chlorine or hydrogen? Explain your answer using the relative molecular masses of the gases.

.....

.....

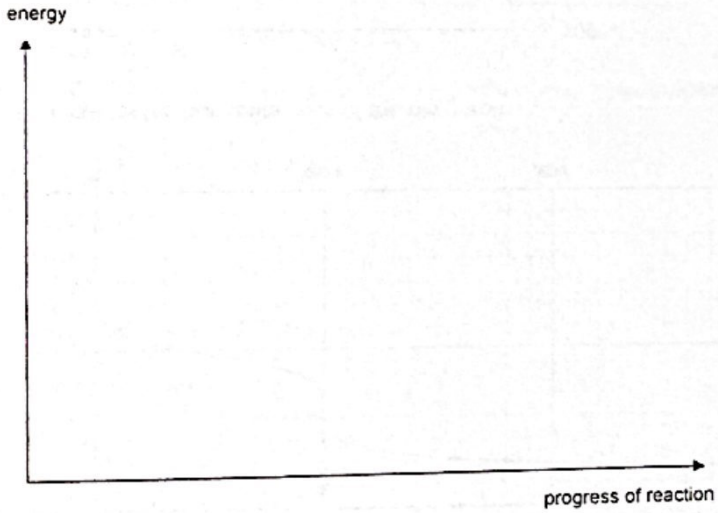
..... [2]

(ii) The enthalpy change for this reaction is +184.6 kJ/mol.

Calculate the enthalpy change when 1 g of HCl is decomposed.
(A_r of H = 1, Cl = 35.5)

[2]

(iii) Draw the energy profile diagram on the axes provided when 1 g of HCl is decomposed. Indicate the activation energy, E_a, and enthalpy change, ΔH.



[3]

[Total: 10]

A4 In the Haber process, the yield of ammonia is only 10 to 15 %. The ammonia produced is used in the making of ammonium salts.

(a) State the temperature required for Haber process.

..... [1]

(b) With the aid of a balanced chemical equation, explain why the yield of ammonia is only 10 to 15 %.

.....

.....

..... [2]

(c) Draw the dot and cross diagram of an ammonium ion. Show valence electrons only.

[2]

(d) Complete the following chemical equation involving an ammonium salt:

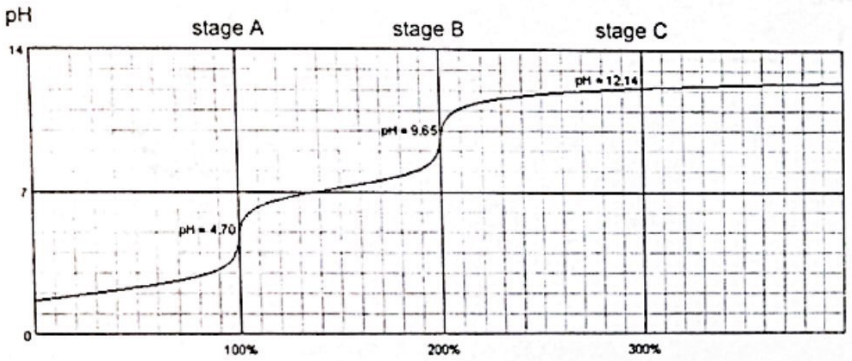
$NH_4NO_3 + KOH \rightarrow$ ..... [1]

[Total: 6]

A5 Phosphoric acid (H_3PO_4) is a corrosive acid that can form three different classes of salts, namely primary phosphates, dibasic phosphates and tribasic phosphates.

It dissociates in a three-step process:
Step 1: $H_3PO_4(aq) \rightleftharpoons H_2PO_4^-(aq) + H^+(aq)$
Step 2: $H_2PO_4^-(aq) \rightleftharpoons HPO_4^{2-}(aq) + H^+(aq)$
Step 3: $HPO_4^{2-}(aq)) \rightleftharpoons PO_4^{3-}(aq) + H^+(aq)$

The pH graph of 0.1 mol/dm^3 of dilute phosphoric acid titrated with 0.1 mol/dm^3 of sodium hydroxide solution (NaOH) is given. The horizontal axis is not labelled and stage C represents the stage when the dilute phosphoric acid is fully neutralised.



(a) Complete the label for the horizontal axis of the pH graph:

$$\frac{\text{volume of .....}}{\text{volume of .....}} \times 100\%$$

[1]

(b) Write the formula of the salt formed at stage A of the titration.

..... [1]

(c) The table shows three indicators and the pH where colour change takes place.

indicator	pH where colour change takes place
methyl orange	3.1 – 4.4
bromothymol blue	6.0 – 7.6
phenolphthalein	8.3 – 10.0

State which indicator can indicate the completion of stage B. Explain your answer.

.....

.....

..... [2]

[Total: 4]

A6 Haematite is an iron ore. It consists of iron(III) oxide and acidic impurities (mainly silicon dioxide) which are insoluble in water.

(a) Name the gaseous compound that is used in the blast furnace to reduce iron(III) oxide to iron.

..... [1]

(b) Describe how the acidic impurities are removed from the iron in the blast furnace.

.....

.....

.....

..... [2]

(c) The method below shows another process to obtain iron from haematite.

Method:

1. Pour some dilute sulfuric acid into a beaker. Warm the acid.
2. Add excess lumps of haematite to the acid and stir the mixture.
3. Filter the mixture with a filter funnel lined with filter paper.
4. Obtain a pure solution of iron(III) sulfate.
5. Add excess zinc powder into the solution.
6. Filter the mixture again to obtain the residue. Remove the iron using a magnet.
7. Wash the iron with deionised water and dry it between sheets of filter paper.

(i) Explain why excess lumps of haematite is added to the acid.

.....

..... [1]

(ii) Explain, using collision theory, why the dissolving of haematite is faster when the dilute sulfuric acid is warmed.

.....

.....

.....

.....

.....

..... [3]

(iii) Write the ionic equation for the reaction between zinc powder and iron(III) sulfate solution.

..... [1]

(iv) A colourless filtrate is obtained in step 6. State the observations made if aqueous ammonia is added to this filtrate, a little at first and then in excess.

.....

.....

..... [2]

[Total: 10]

A7 This table is about two petroleum fractions and their uses.

petroleum fraction	uses
.....	chemical feedstock for petrochemical products
bitumen	.....

(a) Complete the table by filling in the blanks. [2]

(b) Explain why bitumen is found at the bottom of the fractionating column when the fractions are separated.

.....

.....

..... [2]

(c) After separating into fractions, the heavier fractions undergo cracking.

(i) Define the term cracking.

.....

..... [1]

(ii) State the importance of cracking.

.....

..... [1]

[Total: 6]

END OF SECTION A

The Periodic Table of Elements

Group I	II	III	IV	V	VI	VII	0
							2 He helium 4
3 Li lithium 7	4 Be beryllium 9	5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	113 –	114 Fl flerovium –		116 Lv livermorium –		

21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65						
39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112						
57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201						
89 – 103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –						

Key
proton (atomic) number
atomic symbol
name
relative atomic mass

1 H hydrogen 1

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

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This is Section B of the paper.
Answer all three questions, the last question is in the form either/or.
Answer all questions in the spaces provided.
For Question B10, circle your choice of question ('either' or 'or').

The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper (sections A and B) is 80.

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

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(1) Section A
(2) Section B

For Examiner's Use	
Question 8	/10
Question 9	/10
Question 10 Either / Or	/10
Total	/30

This document consists of 10 printed pages.

Section B
Answer three questions.
Question 10 is in the form of an Either/Or question. Only one part should be answered.

B8 Aufbau Principle

The Aufbau principle was initially proposed in 1920 by the Danish physicist Niels Bohr, who was the first person to use quantum mechanics to study atomic structure. He was also one of the first to fundamentally explain the Periodic Table in terms of arrangement of electrons (electron configurations).

The principle uses the concept that electrons will fill the lowest available energy subshell rather than the higher energy subshells. In this way, the electrons in the atoms or ions form the most stable electron configuration possible. As the electrons fill up the subshells in order of increasing energy level, they also get further from the nucleus.

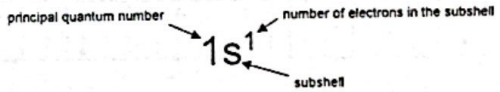
The order in which the electrons fill the energy levels is as follows:

energy	lowest energy → highest energy
subshells	***1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, 7p***

Note: The numbers (1, 2, 3...) represent the principal quantum number for each subshell.

Example:

The electron configuration of hydrogen using the Aufbau principle is given below:



The table below shows the electron configuration of the first 12 elements in the Periodic Table:

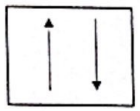
element	atomic number	electron configuration (simplified version)	electron configuration (Aufbau principle)
hydrogen	1	1	$1s^1$
helium	2	2	$1s^2$
lithium	3	2.1	$1s^2 2s^1$
beryllium	4	2.2	$1s^2 2s^2$
boron	5	2.3	$1s^2 2s^2 2p^1$
carbon	6	2.4	-
nitrogen	7	2.5	$1s^2 2s^2 2p^3$
oxygen	8	2.6	$1s^2 2s^2 2p^4$
fluorine	9	2.7	$1s^2 2s^2 2p^5$
neon	10	2.8	$1s^2 2s^2 2p^6$
sodium	11	2.8.1	$1s^2 2s^2 2p^6 3s^1$
magnesium	12	2.8.2	$1s^2 2s^2 2p^6 3s^2$

Pauli Exclusion Principle

In 1925, Wolfgang Pauli theorised that electrons in subshells are placed in smaller units known as orbitals. No more than two electrons can occupy each orbital and the two electrons in the same orbital must have opposing spins.

In the orbital of the 1s subshell, we can fill with a maximum of two electrons and use arrows to represent opposing spins. For example, the two electrons in helium can be represented as below.

He



1s

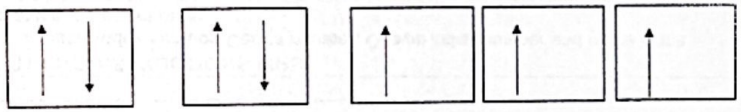
Hund's Rule

A German physicist, Friedrich Hund proposed that the electrons must fill the orbitals in a subshell with the same spin before pairing up.

When visualising this process, think about how electrons are exhibiting the same behavior as the same poles on a magnet would if they came into contact. As the negatively charged electrons fill orbitals, they first try to get as far as possible from each other before having to pair up.

The diagram below shows the electron configuration of nitrogen. The three electrons in the p subshell will fill all the empty orbitals first before filling orbitals with electrons in them.

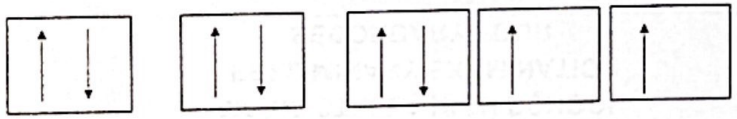
N ($1s^2 2s^2 2p^3$)



1s 2s 2p

The diagram below shows the electron configuration of oxygen. Oxygen has one more electron than nitrogen and as the orbitals are all half-filled with electrons, the remaining electron must pair up.

O ($1s^2 2s^2 2p^4$)



1s 2s 2p

(a) Which subshell is further away from the nucleus, 3s or 3p? Explain your answer.

.....

.....

..... [2]

(b) Suggest the electron configuration of carbon using the Aufbau principle.

..... [1]

(c) Suggest how to determine the period of an element from the electron configurations using the Aufbau principle.

.....

..... [1]

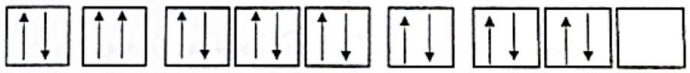
(d) Explain why the electrons must fill the orbitals in a subshell with the same spin before pairing up.

.....

.....

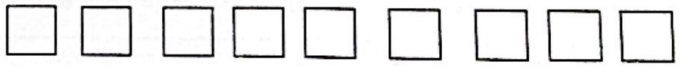
..... [2]

(e) A diagram is incorrectly drawn to represent the electron configuration of a sulfur atom which has 16 electrons.



1s 2s 2p 3s 3p

(i) Correct the mistakes in the diagram and draw the correct diagram below.



1s 2s 2p 3s 3p [2]

(ii) Explain, using Pauli exclusion principle and Hund's rule, why the diagram is incorrectly drawn.

.....

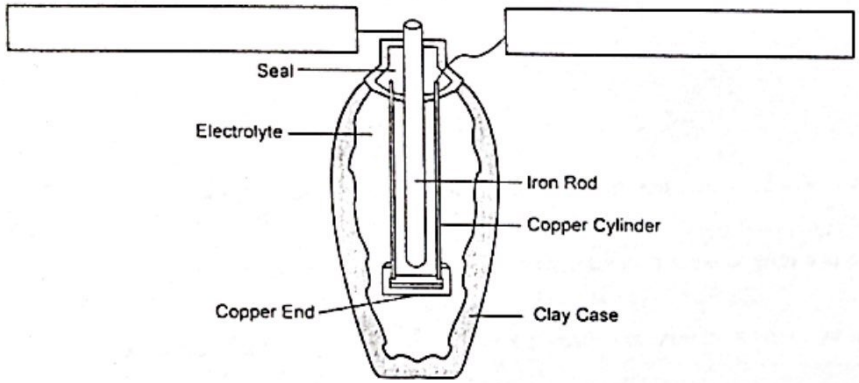
.....

.....

..... [2]

[Total: 10]

B9 The Baghdad battery was first discovered in 1799. It is made of a clay case consisting of a iron rod and a copper cylinder within. It is said to be able to generate electricity when an aqueous electrolyte such as vinegar (ethanoic acid solution) is poured into the case before sealing it.



(a) State the formulae of all the ions present in vinegar.

..... [2]

(b) Label "positive terminal" and "negative terminal" for the battery in the boxes provided. [1]

(c) A model of the battery was made and tested in the laboratory. The voltage was measured to be 0.78 V.

(i) Write the half-equation for the reaction at the positive terminal of the battery.

..... [1]

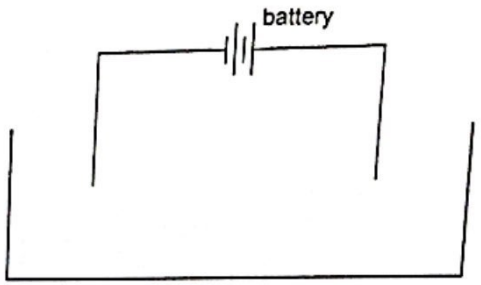
(ii) Suggest one change you can make to the battery to increase the voltage that can be produced.

.....

..... [1]

(d) Scientists concluded that the battery might be used for electroplating of silver onto metal objects.

Draw a labelled diagram to show the set-up for electroplating silver onto a metal object with aqueous silver nitrate electrolyte. The battery, wires and container have been drawn for you.



State and explain what happens to the set-up after it has been running for some time.

- Include half-equations for the reactions at the electrodes.
- State and explain the changes (if any) to the masses of the electrodes.
- State and explain the change (if any) to the concentration of the electrolyte.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 10]

Either

B10 (a) Bioethanol is a form of renewal energy made from common crops such as corn, sugarcane and potato. It is considered as a fuel which do not increase the amount of carbon dioxide in the atmosphere.

Explain why bioethanol is considered as a fuel which do not increase the amount of carbon dioxide in the atmosphere.

.....

.....

..... [2]

(b) The formation of ethanol follows the steps below:

- Heat the sugar solution to a suitable temperature and pour it into a container.
- The rate of reaction increases when yeast is added to the sugar solution.
- The container is sealed.
- The reaction stops when the percentage by volume of ethanol reaches 14%.
- The resulting solution undergoes further separation to obtain ethanol of higher purity.

(i) Write the balanced chemical equation for the formation of ethanol from sugar.

..... [1]

(ii) Explain why the rate of reaction increases when the yeast is added.

.....

..... [1]

(iii) Explain why the reaction stops when the percentage by volume of ethanol reaches 14%.

.....

..... [1]

(c) Alcoholic drinks contain ethanol. To test for alcohol intake, a breath analyser can be used.

The earliest breath analyser uses the colour change when acidified potassium dichromate(VI) solution, $K_2Cr_2O_7$ (orange) reacts with ethanol to produce chromium(III) sulfate, $Cr_2(SO_4)_3$ (green). In a balanced chemical equation, 2 moles of ethanol react with 3 moles of potassium dichromate(VI).

Blood alcohol content (BAC) can be calculated using the Widmark equation:

$$\text{BAC} = \frac{[\text{Ethanol consumed (g)} \times 100\%]}{[\text{body weight (g)} \times r]}$$

The values of r are often taken to be 0.55 for females and 0.68 for males.

(i) Suggest another chemical commonly found in the laboratory that can be used to test for the presence of ethanol using colour change.

..... [1]

(ii) Explain, using oxidation state, whether the potassium dichromate(VI) was oxidised or reduced when it reacts with ethanol.

.....

..... [1]

(iii) Drivers with BAC at 0.08% is unable to accurately retrieve signals from their brains to either their hands on the steering wheel or feet on the brake pedal.

A can of alcoholic drink, containing ethanol, was titrated with 2 mol/dm^3 of acidified potassium dichromate(VI) solution. There was a permanent colour change when 36.50 cm^3 of acidified potassium dichromate(VI) solution was added.

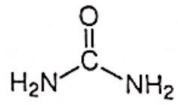
Calculate the maximum number of cans of this alcoholic drink a man of 60 kg can consume before he reaches the limit of 0.08%.
(A_r of C = 12, H = 1, O = 16)

[3]

[Total: 10]

Or

B10 Urea, also known as carbamide, is an organic compound with the formula $CO(NH_2)_2$.



It can be synthesised with two inorganic compounds, ammonia and carbon dioxide. It is a colourless, odourless solid and highly soluble in water.

(a) 2 moles of ammonia and 1 mole of carbon dioxide forms 1 mole of urea and one other product.

Write the balanced chemical equation of the formation of urea from ammonia and carbon dioxide.

..... [1]

(b) Calculate the mass of ammonia in kg needed to produce 500 kg of urea.
(A_r of N = 14, H = 1, C = 12, O = 16)

[2]

(c) Urea can be used in vehicle engines to reduce oxides of nitrogen into nitrogen found in the exhaust gas.

Step 1: $CO(NH_2)_2 + H_2O \rightarrow 2NH_3 + CO_2$
Step 2: $4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$

(i) Explain how oxides of nitrogen are formed in vehicle engines.

..... [1]

(ii) Write an overall equation for the reaction between urea and nitrogen monoxide

..... [1]

(d) Urea can undergo condensation polymerisation with a dicarboxylic acid, X.

(i) X is a straight-chain organic compound that has a composition by mass given in the table and a relative molecular mass of 118.

Element	Composition by mass (%)
C	40.68
H	5.08
O	54.24

Deduce the molecular formula of X.
(A_r of C = 12, H = 1, O = 16)

[3]

(ii) Draw the full structural formula of X and hence draw the full structural formula of one repeat unit of the polymer formed by urea and X in the boxes provided.

full structural formula of X

one repeat unit of polymer formed by urea and X

[2]

[Total: 10]

END OF SECTION B

Class/ Index Number	Centre Number/ 'O' Level Index Number	Name
/	/	

新加坡海星中学

MARIS STELLA HIGH SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR

CHEMISTRY **6092/01**
Paper 1 Multiple Choice **30 August 2023**
1 hour

Additional Materials:
Optical Test Answer Sheet (OTAS) – 1 sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your class, index number, Centre number, O level index number and name in the spaces at the top of this page.

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A, B, C** and **D**.
Choose the **one** you consider correct and record your answer in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

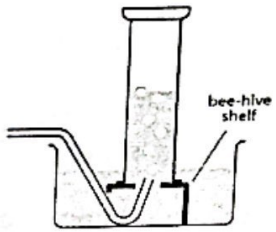
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this question booklet.
A copy of the Periodic Table is printed on page 16.
The use of an approved scientific calculator is expected, where appropriate.

The total number of marks for this paper is 40.

At the end of the examination, hand in the following separately:
(1) Optical Test Answer Sheet (OTAS)
(2) Question Paper

1 Gases produced in chemical reactions can be collected for future usage.

An experiment was conducted where reactants were placed into a conical flask and the gas produced was collected using displacement of water method as shown below.



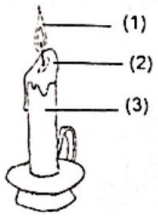
Which of the following reactions is this method not suitable?

A decomposition of aqueous hydrogen peroxide
B decomposition of calcium carbonate
C reacting magnesium metal with dilute sulfuric acid
D reacting ammonium chloride and dilute potassium hydroxide

2 Which of the following pairs of substances can be separated by heating?

A ammonium chloride and sodium chloride
B ammonium chloride and solid iodine
C magnesium oxide and silver carbonate
D magnesium oxide and copper

3 The diagram below shows a burning candle.



Which of the following shows the correct description of the movement of the particles in (1), (2) and (3)?

	(1)	(2)	(3)
A	particles move randomly in any direction	particles vibrate in fixed positions	particles can rotate and slide over one another
B	particles move randomly in any direction	particles can rotate and slide over one another	particles vibrate in fixed positions
C	particles can rotate and slide over one another	particles move randomly in any direction	particles vibrate in fixed positions
D	particles vibrate in fixed positions	particles can rotate and slide over one another	particles move randomly in any direction

4 Chromatography was used to separate a mixture containing two dyes. The R_f values of two dyes are given in the following table.

dye	X	Y
R_f	0.60	0.40

If dye X moves a distance of 9 cm from the starting line, what is the distance between dyes X and Y on the same chromatogram?

A 1 cm B 2 cm C 3 cm D 4 cm

5 The solubility of four solids, P, Q, R and S are as shown in the table below.

	P	Q	R	S
solubility in water	soluble	insoluble	insoluble	soluble

Kevin tried to separate mixtures of these solids using the following steps.

1) Add the mixture to a beaker of water and stir.
2) Filter the mixture.
3) Obtain one of the solids from the mixture using crystallisation.

Which of the following mixtures could not be separated by this method?

A P and R
B Q and P
C Q and R
D R and S

6 An ion X^{3-} has a mass number of **m** and **n** electrons.

What does the nucleus of an atom of X contain?

	number of protons	number of neutrons
A	n - 3	n - m
B	n - 3	m – (n - 3)
C	n + 3	m – (n + 3)
D	n + 3	m + n

7 A sample of silver metal consists of 2 stable isotopes, 51.8% of silver-107 and 48.2% of silver-109. What is the average relative atomic mass of the metal?

A 106 B 107 C 108 D 109

8 Which of the following consists of compounds only?

A silver nitrate, copper(II) sulfate solution, magnesium oxide
B carbon monoxide, propane, carbon dioxide
C bronze, steel, pewter
D graphite, calcium, limestone

9 When a saturated aqueous solution of ammonium cobalt(II) sulfate hexahydrate, $(NH_4)_2Co(SO_4)_2.6H_2O$ is cooled from 60 °C to room temperature, crystals are formed. Which statement about this process is correct?

A The mass of the solvent in the solution increases.
B The concentration of the solution remains the same.
C The mass of the solute dissolved in the solution decreases.
D The solubility of the solute increases as the temperature falls.

10 Which of the following consists of substance containing both ionic and covalent bonds?

A aluminium sulfate
B beryllium chloride
C sulfur dioxide gas
D chromium oxide

11 Capsaicin, which is found in chilli and pepper, causes the spicy burning sensation in the mouth

It has the molecular formula $C_{18}H_{27}NO_3$ and has a melting point of 65 °C.

Which of the following statements best explains why drinking water is ineffective in removing the burning sensation caused by capsaicin?

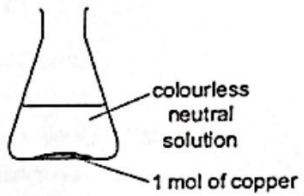
A Capsaicin has a giant molecular structure and is soluble in water.
B Capsaicin has a giant molecular structure and is not very soluble in water.
C Capsaicin has a simple molecular structure and is soluble in water.
D Capsaicin has a simple molecular structure and is not very soluble in water.

12 In an experiment, 1 mol of powdered copper and 1 mol of powdered zinc are placed in a flask. 3 mol of hydrochloric acid is then added to the flask.

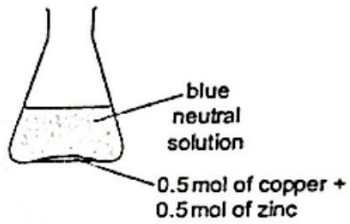
The flask is left until all the reactions, if any, are completed.

Which diagram shows the results of the experiment?

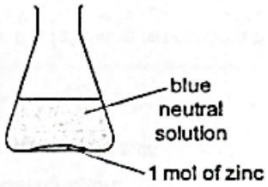
A



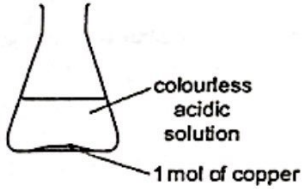
B



C



D



13 49.2 g of hydrated magnesium sulfate is heated and cooled repeatedly until it reaches a constant mass of 24.0 g.

Assuming only water of crystallisation is lost when hydrated magnesium sulfate is heated, what is the formula of the hydrated magnesium sulfate? (A_r of Mg=24, S=32, O=16, H=1)

A $MgSO_4.H_2O$
B $MgSO_4.3H_2O$
C $MgSO_4.5H_2O$
D $MgSO_4.7H_2O$

14 The formula of an oxide of element X is X_3O.

5.9 g of X_3O contains 4.3 g of X.

How many moles of X ions does 5.9 g of X_3O contain?

A $\frac{1.6}{16} \div 3$

B $\frac{1.6}{16} \times 3$

C $\frac{5.9}{16 \times 3}$

D $\frac{5.9}{16} \times 3$

15 A student wishes to dilute a solution of sodium hydroxide. Calculate the volume of deionised water that she needs to add to 20.0 cm^3 of 2.00 mol/dm^3 sodium hydroxide so that the concentration of the resulting solution is 0.300 mol/dm^3.

A 0.200 dm^3 B 0.245 dm^3

C 0.113 dm^3 D 0.040 dm^3

16 A piece of iron metal does not react when it was placed into a solution of hydrogen chloride dissolved in methylbenzene, an organic solvent.

Which modification will allow the iron to react?

A add water and stir

B increase the surface area of iron metal

C bubble more hydrogen chloride gas into the mixture

D sand paper the piece of iron metal

17 Which of the following is/are suitable methods to test the strength of both nitric acid and ethanoic acid of the same concentration?

I using a pH meter

II measuring their electrical conductivity

III titration using potassium hydroxide solution

A I and II B III only

C I and III D I, II and III

18 Y is a black solid with formula Ga_2O_3. A reaction took place as followed.

$$Ga_2O_3 + 2KOH \rightarrow 2KGaO_2 + H_2O$$

What is the role of Y in the reaction? It is acting as a/an _____.

A acidic oxide

B basic oxide

C neutral oxide

D amphoteric oxide

19 Which of the following can be used to distinguish between a solution of aluminium nitrate and lead(II) nitrate?

A bromine solution B aqueous sodium hydroxide

C dilute sulfuric acid D aqueous hydrogen peroxide

20 Which of the following can be used to test for chlorine gas?

A litmus paper

B cobalt(II) chloride paper

C locating agent

D concentrated sulfuric acid

21 Which of the following represents the overall reaction in the hydrogen-oxygen fuel cell?

A $KOH + HCl \rightarrow KCl + H_2O$

B $2H_2O_2 \rightarrow O_2 + 2H_2O$

C $2H_2O \rightarrow 2H_2 + O_2$

D $2H_2 + O_2 \rightarrow 2H_2O$

22 A study of a precipitation reaction between aqueous lead(II) nitrate and dilute sulfuric acid of the same concentration was conducted.

Test tubes 1 to 4 contain different volumes of aqueous lead(II) nitrate and dilute sulfuric acid.

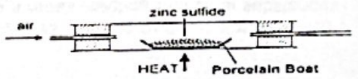
Precipitation occurs in all test tubes and after 10 minutes, the height of the precipitate in each test tube is measured and recorded.

Test tube	1	2	3	4
volume of aqueous lead (II) nitrate / cm^3	5.0	5.0	5.0	5.0
volume of sulfuric acid / cm^3	3.0	4.0	5.0	6.0
height of precipitate / cm	3.0	3.5	4.0	4.0

At the end of reaction, which test tube contains excess sulfuric acid?

A 1 B 2
C 3 D 4

23 Zinc is extracted from its ore, zinc sulfide, which is heated in air to form zinc oxide and a gas. This was carried out in a laboratory using the apparatus shown.



What are the observations in the porcelain boat and gas formed while zinc sulfide is being heated?

	solid in porcelain boat	gas formed
A	turns yellow	sulfur dioxide
B	turns yellow	oxygen
C	turns grey	oxygen
D	turns white	sulfur dioxide

24 A substance is coated on iron to prevent it from rusting. Which substance, when scratched, will cause the underlying iron to rust most quickly?

A paint B grease
C tin D zinc

25 Which of the following property does not describe a property of Group I elements?

A good conductor of electricity
B do not react with steam
C react readily with halogens
D have low densities

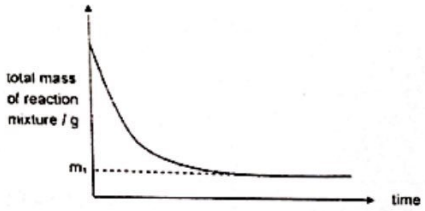
26 In separate experiments conducted, a gaseous halogen was bubbled into an aqueous solution of a halide salt. The following results were observed.

experiment	halogen added	halide solution		
		X^-	Y^-	Z^-
1	X_2	-	displaced as Y_2	displaced as Z_2
2	Y_2	no visible reaction		displaced as Z_2
3	Z_2	no visible reaction	no visible reaction	

What is the arrangement of the halogens X, Y and Z in group VII, in increasing order of proton number?

A X, Y, Z B X, Z, Y
C Z, Y, X D Y, X, Z

27 When excess copper(II) carbonate is added to dilute sulfuric acid, the total mass of the reaction mixture is measured over a period of time as shown in the graph below.



Which is the composition of mass m_1?

A copper(II) sulfate solution
B copper(II) sulfate solution and carbon dioxide
C copper(II) sulfate solution, unreacted copper(II) carbonate
D copper(II) sulfate solution, excess dilute sulfuric acid

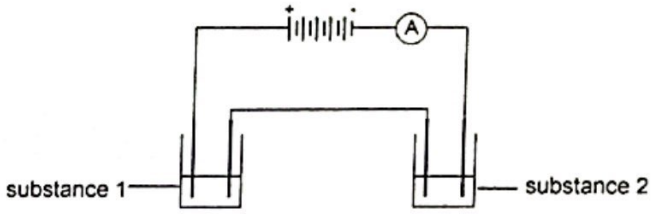
28 Nitric acid, HNO_3, can act as a strong oxidising agent. Which of the following cannot be a product of nitric acid in a redox reaction with other substances?

A N_2 B NO
C NO_2 D N_2O_5

29 If the oxidation states of X, Y and Z are +1, +5 and -2 respectively, what is the value of n, the charge of the ion $(X_2YZ_4)^n$?

A -1 B -5
C +1 D +5

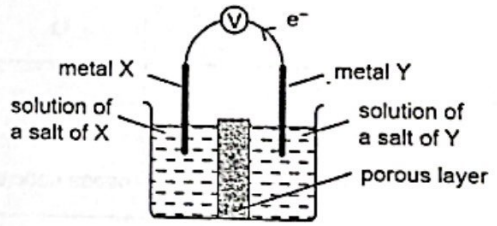
30 The following diagram shows an electrolytic cell set-up.



Which of the following pairs of substances in the beakers will give the largest current reading on the ammeter?

	substance 1	substance 2
A	solid potassium chloride	dilute nitric acid
B	dilute sulfuric acid	propanol
C	dilute ethanoic acid	molten aluminium chloride
D	molten magnesium chloride	dilute sulfuric acid

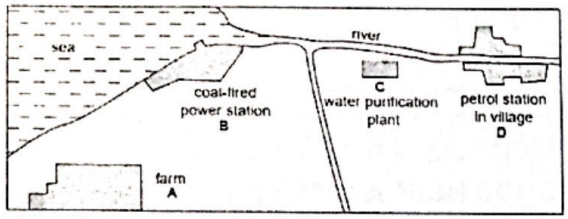
31 The direction of electron flow in the simple cell shown below is from metal Y to metal X.



Which pair of metals X and Y will produce the highest voltage when used as electrodes in the simple cell?

	metal X	metal Y
A	copper	aluminium
B	iron	magnesium
C	iron	zinc
D	silver	magnesium

32 Which place on the map is most likely to be producing large quantities of sulfur dioxide?



33 To reduce atmospheric pollution, the following waste gases from a coal-burning power station are passed through aqueous calcium hydroxide.

carbon dioxide	carbon monoxide	nitrogen dioxide
sulfur dioxide	phosphorus(V) oxide	propene

How many waste gases will not be removed by the above process?

A 2 B 3 C 4 D 5

34 Which air pollutant irritates, damages the lungs and is a cause of acid rain?

A carbon monoxide
B oxides of nitrogen
C methane
D ozone

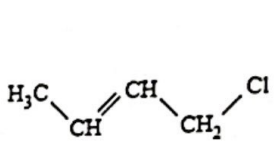
35 Which of the following releases heat and involves the smallest change in volume for the same mass of substance?

A condensation B sublimation
C boiling D freezing

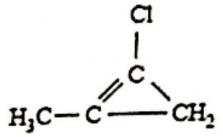
36 An unsaturated organic acid P has the formula $C_{17}H_{29}COOH$. How many double bonds are present between carbon atoms in each molecule of P?

A 2 B 3 C 4 D 5

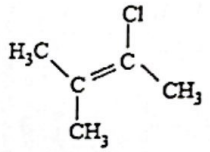
37 Some molecules are shown below.



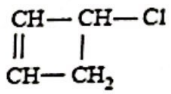
(I)



(II)



(III)



(IV)

Which of the following represents a pair of isomers?

A I and II
B I and III
C I and IV
D II and IV

38 A group of students wrote the names of some esters as shown below.

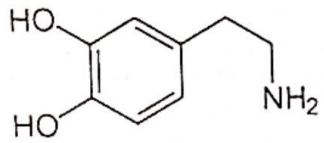
I methyl ethanoate
II ethyl propanoate
III ethyl methanoate
IV propyl methanoate

Which esters have the same molecular formula, $C_3H_6O_2$?

A I and II
B I and III
C II and IV
D III and IV

39 Dopamine is a chemical released in the brain that makes you feel good. Having the right amount of dopamine is important both for your body and your brain.

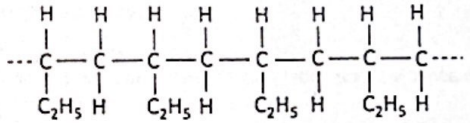
The full structural formula of dopamine is as shown below.



Which of the following substances can dopamine react with?

A nitrogen
B oxygen
C butane
D ammonia

40 Part of a polymer has the structure as shown below.



What is the molecular formula of the monomer?

A C_2H_6
B C_3H_9
C C_4H_6
D C_8H_{16}

End of Paper

The Periodic Table of Elements

Group I	II											III	IV	V	VI	VII	0
																	2 He helium 4
												5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
												13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
3 Li lithium 7	4 Be beryllium 9											31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
11 Na sodium 23	12 Mg magnesium 24											49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	80 Hg mercury 201	114 Fl flerovium –		116 Lv livermorium –		
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	111 Rg roentgenium –	112 Cn copernicium –					
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –						

Key
proton (atomic) number
atomic symbol
name
relative atomic mass

1 H hydrogen 1

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium -	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

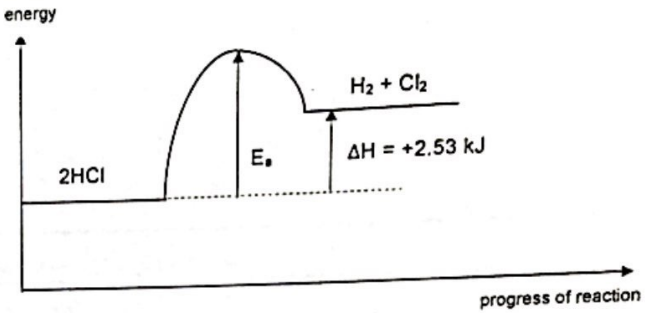
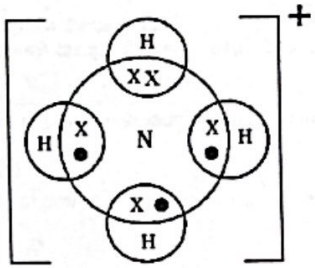
2023 S4 Prelim Paper 1 Answer

1	D	2	A	3	B	4	C	5	C	6	B	7	C	8	B	9	C	10	A
11	D	12	D	13	D	14	B	15	C	16	A	17	A	18	D	19	C	20	A
21	D	22	D	23	A	24	C	25	B	26	A	27	C	28	D	29	A	30	D
31	D	32	B	33	A	34	B	35	D	36	B	37	D	38	B	39	B	40	C

Suggested Answers to Sec 4 Chemistry Prelim Paper 2 2023

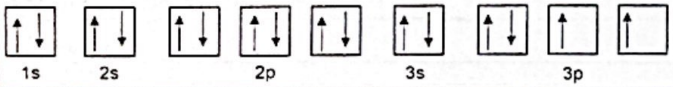
Section A

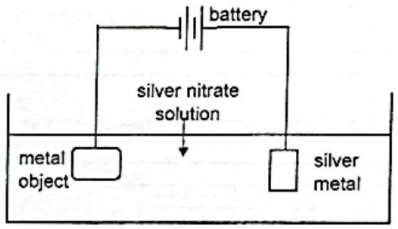
Qn	Answers
A1	
ai	B and E
ii	C
iii	D
iv	H
b	Add substance A and B separately into a test tube of aqueous bromine. Shake the test tube. / Bubble A and B into a test tube of aqueous bromine. The test tube with substance A will have no visible change. The test tube with substance B will decolourise the aqueous bromine.
A2	
a	Insoluble in water
b	Graphite can conduct electricity. Each carbon atom in graphite is bonded with three other carbon atoms. There is one electron that is delocalised / free to move along the layers to conduct electricity. or Graphite is soft/slippery. There are weak Van der Waals forces between the layers in graphite. The layers can slide past one another easily.
c	Vibrating about fixed positions to sliding past one another
d	Fullerene has a simple molecular structure. Small amount of energy is needed to overcome the weak intermolecular forces of attraction between the molecules.
A3	
a	The higher the reactivity of the halogen, higher the bond strength of the hydrogen halide.
b	HI The bond strength of HI is lower/Lower energy is needed to break the HI bond. Higher concentration of hydrogen ions per unit time is formed when HI dissociates in water. / HI is more readily dissociated in water than HCl.
ci	Hydrogen. The relative molecular mass of hydrogen (Mr = 2) is lower than that of chlorine (Mr = 71), hence the hydrogen gas molecules diffuse faster than the chlorine molecules.
ii	No. of moles of HCl = $\frac{1}{36.5}$ = 0.027397 Enthalpy change = 0.027397 x $\frac{184.6}{2}$ = +2.53 kJ (3sf)

iii	
A4	
a	450 °C
b	$3H_2 + N_2 \rightleftharpoons 2NH_3$ The reaction is reversible / Some of the ammonia breaks down to form hydrogen and nitrogen.
c	
d	$NH_4NO_3 + KOH \rightarrow KNO_3 + NH_3 + H_2O$
A5	
a	$\frac{volume\ of\ NaOH}{volume\ of\ H_3PO_4} \times 100\%$
b	NaH_2PO_4
c	Phenolphthalein The equivalence point for stage B is within the pH range where phenolphthalein changes colour.
A6	
a	Carbon monoxide
b	Limestone (calcium carbonate) thermally decomposed to form calcium oxide and carbon dioxide. The calcium oxide reacts with the acidic impurities (silicon dioxide) to form slag (calcium silicate) which is then removed from the blast furnace.

ci	This is to ensure that all the acid is used up.
cii	The particles of sulfuric acid gains kinetic energy / moves faster. More particles have energy that can overcome activation energy. There is increase in the frequency of effective collisions, increasing speed of reaction.
ciii	$3Zn\ (s) + 2Fe^{3+}\ (aq) \rightarrow 3Zn^{2+}\ (aq) + 2Fe\ (s)$
civ	White precipitate is produced when a little aqueous ammonia is added. The precipitate dissolved in excess aqueous ammonia, forming a colourless solution.
A7	
a	naphtha paving of road surface
b	Bitumen has the highest range of boiling points. It cools and condenses first and is collected at the bottom of the fractionating column.
ci	Cracking is the breaking down of long-chain hydrocarbons to produce short-chain hydrocarbons.
cii	Cracking is required to meet the (high) demand of short-chain hydrocarbons which are in low supply.

Section B

Qn	Answers
B8	
a	3p. Since 3p has a higher energy level than 3s, it is further away from the nucleus.
b	$1s^2 2s^2 2p^2$
c	The period is determined by the largest principal quantum number / principal number of the last subshell.
d	Electrons have the same charge. They fill the orbitals in the subshells with the same spin to minimize repulsion.
ei	
eii	Pauli exclusion principle states that electrons in the same orbital must have opposing spins, but the electrons in 2s have the same spin. Hund's rule states that the electrons must fill the orbitals in a subshell with the same spin before pairing up, but the electrons in 3p did not fill up all the orbitals with the same spin before pairing up.

B9	
a	H^+, OH^-, CH_3COO^-
b	Copper – positive terminal Iron – negative terminal
ci	$2H^+\ (aq) + 2e^- \rightarrow H_2\ (g)$
ii	Change the iron to a more reactive metal (zinc, magnesium) / Change the copper to a less reactive metal (silver, gold)
d	 container Draw and label electrodes and aqueous electrolyte At the anode: $Ag\ (s) \rightarrow Ag^+\ (aq) + e^-$ At the cathode: $Ag^+\ (aq) + e^- \rightarrow Ag\ (s)$ Silver anode oxidises to form silver ions which goes into the solution. The anode loses mass. Silver ions are selectively discharged over hydrogen ions because they receive ions more readily. The cathode gains mass. The concentration of the electrolyte remains the same as the silver ions that are selectively discharged at the cathode is replenished by the silver ions produced at the anode.
B10	EITHER
a	Bioethanol is made from plants (corn, sugarcane, potato) that take in carbon dioxide for photosynthesis. This balances the carbon dioxide given out during combustion of bioethanol.
bi	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

ii	Yeast is a catalyst for the reaction. / Yeast helps the sugar to decompose faster. / Yeast lowers the activation energy needed for the reaction.
iii	The yeast is denatured / cannot function as a catalyst. / Alcohol (at 14%) is toxic to yeast. / Alcohol (at 14%) changes the structure of the yeast.
ci	(acidified) potassium manganate(VII) (solution)
ii	Potassium dichromate(VI) is reduced as the oxidation state of chromium decreases from +6 in potassium dichromate(VI) to +3 in chromium(III) sulfate / chromium(III) ion.
iii	No. of moles of potassium dichromate(VI) = 0.0365 x 2 = 0.073 2 mole of ethanol reacts with 3 moles of potassium dichromate(VI) 0 048667 mole of ethanol reacts with 0.073 moles of potassium dichromate(VI) Mass of ethanol in one drink = 0.048667 x 46 = 2.2387g Mass of ethanol at BAC = 0.08% 0.08% = $\frac{Mass\ of\ ethanol \times 100\%}{60000 \times 0.68}$ Mass of ethanol at 0.08% = (0.08 x 60000 x 0.68) ÷ 100 = 32.64g Number of cans = 32.64 ÷ 2.23867 = 14.58 = 14 drinks (round down to nearest whole number)
B10	OR
a	$2NH_3 + CO_2 \rightarrow CO(NH_2)_2 + H_2O$
b	No. of moles of urea = 500000 ÷ 60 = 8333.33 2 mole of ammonia produces 1 mole of urea 16666.67 mole of ammonia reacts with 8333.33 moles of urea Mass of ammonia = 16666.67 x 17 = 283333.33g = 283 kg (3sf) Or 2 mole of ammonia produces 1 mole of urea 34 g of ammonia produces 60 g of urea 34 kg of ammonia produces 60 kg of urea (34 ÷ 60) x 500 = 283 kg (3sf) of ammonia produces 500 kg of urea
ci	The high temperature of the engine caused the nitrogen and oxygen in the air to form oxides to nitrogen.
ii	$2CO(NH_2)_2 + 4NO + O_2 \rightarrow 2CO_2 + 4N_2 + 4H_2O$

di

	C	H	O
Mass of element in 100g (g)	40.68	5.08	54.24
Molar mass (g/mol)	12	1	16
No. of moles of each element	40.68 ÷ 12 = 3.39	5.08 ÷ 1 = 5.08	54.24 ÷ 16 = 3.39
Mole ratio	3.39 ÷ 3.39 = 1 1 x 2 = 2	5.08 ÷ 3.39 = 1.498 ≈ 1.5 1.5 x 2 = 3	3.39 ÷ 3.39 = 1 1 x 2 = 2

Empirical formula = $C_2H_3O_2$

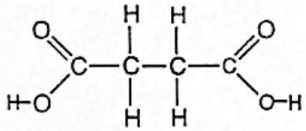
Let the molecular formula be $C_{2n}H_{3n}O_{2n}$

n = 118 ÷ (12 x 2 + 3 x 1 + 16 x 2) = 2

Molecular formula is $C_4H_6O_4$

ii

Full structural formula of X



Full structural formula of one repeat unit of the polymer formed by urea and X