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Preliminary Examination 2016
Secondary Four Express & Five Normal

CANDIDATE NAME:

CLASS: / INDEX NUMBER:

CHEMISTRY

5073/01

Paper 1 Multiple Choice

24 August 2016

1 hour

1315 – 1415h

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name, class and index number on the Answer Sheet in the spaces provided.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C, D.**
Choose the one you consider correct and record your choice **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 the wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page **15.**

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

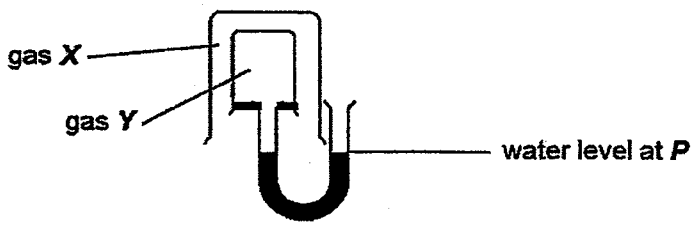
1 Benzoic acid is widely used in the food industry as a food preservative. The melting and boiling points of benzoic acid are given below.

- melting point of 122°C
- boiling point of 249°C

Which of the following will occur to the particles of benzoic acid when it is cooled from 500°C to 100°C?

	distance between particles	energy of particles
A	decreases	decreases
B	increases	decreases
C	increases	increases
D	decreases	increases

2 Which pair of gases could be ***X*** and ***Y*** that will cause a decrease in the water level at ***P***?

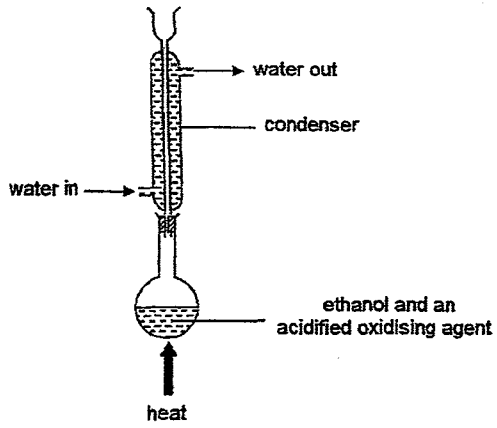


	gas ***X***	gas ***Y***
A	carbon monoxide	fluorine
B	fluorine	neon
C	methane	oxygen
D	nitrogen	carbon dioxide

3 Aminoaciduria refers to a medical condition in which certain types of amino acids in the urine are present in abnormal amount. Which of the following methods can be used by doctors to separate and identify the amino acids from a sample of urine?

A chromatography
B crystallisation
C filtration
D fractional distillation

4 The following apparatus is commonly used to oxidise ethanol to ethanoic acid.



The purpose of the condenser is used to prevent

A air from oxidizing ethanoic acid formed.
B ethanoic acid from reforming back to ethanol.
C ethanol from being converted to ethene.
D the escape of any unreacted ethanol.

5 A mixture of manganese(IV) oxide and sulfur may be separated by the procedure below.

Step 1: The mixture is added into carbon disulfide and stirred.
Step 2: The resulting mixture is filtered to remove manganese(IV) oxide as the residue.
Step 3: The filtrate is distilled to recover the sulfur and the distillate is condensed by using a condenser.

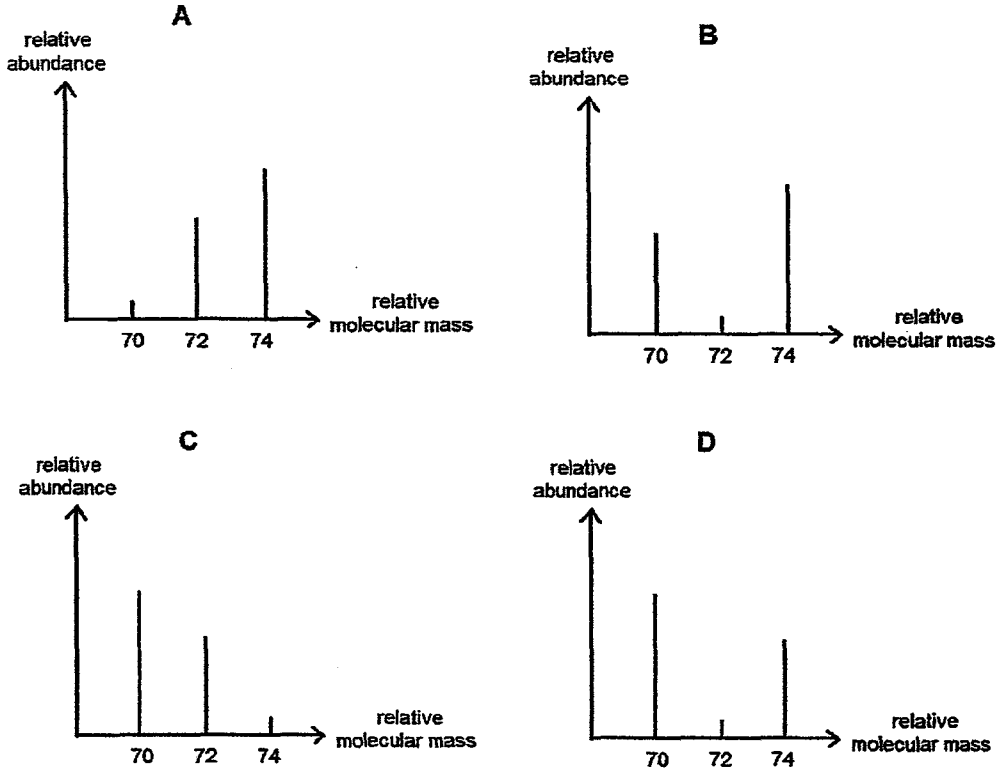
Which one of the following **cannot** be deduced from the above procedure?

A Carbon disulfide has a boiling point just above that of water.
B Manganese(IV) oxide does not react with carbon disulfide.
C Sulfur is soluble in carbon disulfide.
D Sulfur is stable to heating.

6 A new substance was discovered and a series of experiments were conducted on it. Which observation suggests that the substance **cannot** be an element?

A Electrolysis of the molten substance gives two products.
B It dissolves in water to give a colourless solution.
C When exposed to air, it crumbles to a white powder.
D When heated in air, it forms a white solid.

7 Chlorine has two isotopes, ^{35}Cl and ^{37}Cl, in the ratio of 3 atoms of ^{35}Cl to 1 atom of ^{37}Cl. Thus, diatomic molecules formed by chlorine have three possible relative molecular mass, 70, 72 and 74. Which of the following shows the correct relative abundance of the molecules formed by chlorine?



8 Three different atoms, ***H***, ***D*** and ***O*** are represented as $^{1}_{1}H$, $^{2}_{1}D$ and $^{16}_{8}O$ respectively.

Which ion formed by these atoms has more electrons than protons, and more protons than neutrons?

A D^-
B H^+
C OD^-
D OH^-

9 An element ***X*** has an electronic configuration 2.2. The compound formed when ***X*** combines with chlorine is most likely to be

A a compound with a low melting point.
B a gas that dissolves in water to form an electrolyte.
C a good conductor in both solid and molten state.
D an ionic solid.

10 The reaction between dinitrogen monoxide and hydrogen is shown.

$$w\,N_2O + x\,H_2 \rightarrow y\,NH_3 + z\,H_2O$$

Which of the followings shows a balanced equation for the reaction above?

	w	*x*	*y*	*z*
A	1	1	1	2
B	1	2	1	1
C	1	2	2	1
D	1	4	2	1

11 The volume of gas inside a detergent bubble floating in the air depends on the total number of moles of gas inside it. Which of these bubbles would have the largest volume at room temperature and pressure?

A
4.0×10^{19} of molecules hydrogen

B
7.0×10^{-4} moles of ethane gas

C
4.0 mg of helium

D
7.0×10^{-4} moles of ethene gas

12 What is the concentration of 2.5 dm^3 of dilute hydrochloric acid needed to react completely with 100 g of calcium carbonate which is only 85% pure?

A 0.34 mol/dm^3
B 0.40 mol/dm^3
C 0.68 mol/dm^3
D 0.80 mol/dm^3

13 The combustion reaction between hydrogen gas and oxygen gas is shown.

$$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(g)$$

A mixture of 24 dm^3 of hydrogen gas and 100 dm^3 of oxygen gas was ignited. The reaction mixture was cooled to room temperature and pressure. What would be the total volume of gases remaining at the end of the reaction?

A 66 dm^3
B 76 dm^3
C 88 dm^3
D 112 dm^3

14 Which of the following does **not** show the appropriate reagents used for preparation of the named salts?

	salt	reagents
A	barium sulfate	barium nitrate solution + sulfuric acid
B	lead (II) chloride	lead (II) carbonate + hydrochloric acid
C	lithium nitrate	lithium hydroxide solution + nitric acid
D	magnesium chloride	magnesium + hydrochloric acid

15 Which of the following solutions will give a precipitate when added to dilute sulfuric acid?

A aluminium nitrate
B calcium nitrate
C silver nitrate
D zinc nitrate

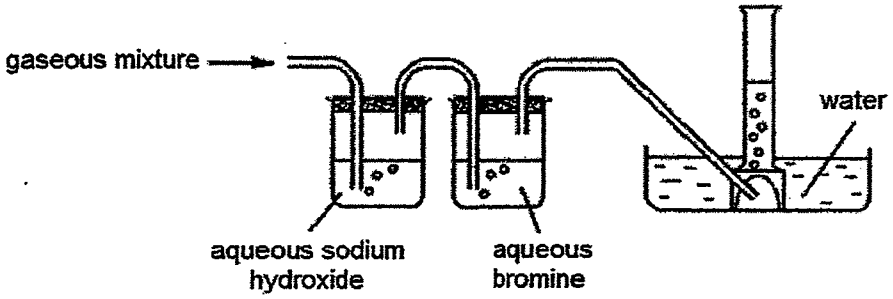
16 A mixture of the oxides of two elements of the third period is dissolved in water. This solution is approximately neutral. What could be the constituents of the mixture?

A Al_2O_3 and Na_2O
B Na_2O and MgO
C Na_2O and P_4O_{10}
D SO_3 and P_4O_{10}

17 In which of the following reactions is zinc hydroxide **not** behaving as a base?

A $Zn(OH)_2 + 2HCl \rightarrow ZnCl_2 + 2H_2O$
B $Zn(OH)_2 + 2NaOH \rightarrow Na_2Zn(OH)_4$
C $3Zn(OH)_2 + 2H_3PO_4 \rightarrow Zn_3(PO_4)_2 + 6H_2O$
D $Zn(OH)_2 + (NH_4)_2SO_4 \rightarrow ZnSO_4 + 2NH_3 + 2H_2O$

18 A gaseous mixture of ethene, oxygen and sulfur dioxide is passed through the apparatus shown. Only one of the gases is collected.



Which of the following is a property of the gas collected?

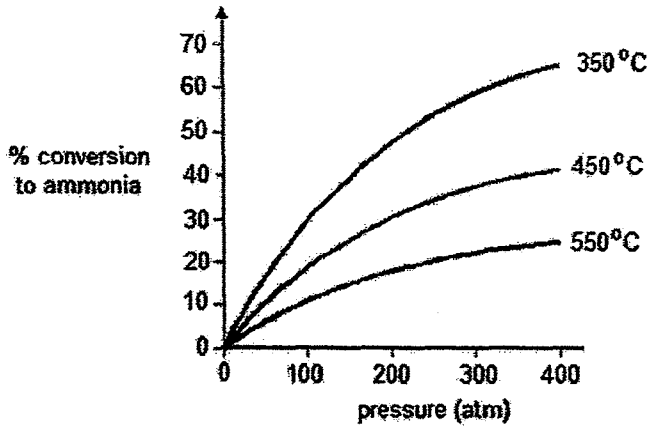
A It burns with a yellow flame.
B It forms white precipitate in limewater.
C It relights a glowing splint.
D It turns moist blue litmus paper to red.

19 Which of the following are true of the Haber process?

I Ammonia formed is condensed and obtained as a liquid.
II Hydrogen gas used is obtained from cracking of petroleum.
III Iron catalyst is used to increase the yield of ammonia.
IV Nitrogen gas is oxidised to form ammonia.

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

20 The following graph shows the different yields of ammonia at different temperatures and pressures.



Which of the following is **not** true?

A A higher percentage yield of ammonia can be obtained at higher pressures.
B A higher percentage yield of ammonia can be obtained at lower temperatures.
C Ammonia is produced at all conditions of temperatures and pressures.
D At 500°C and 300 atm, the percentage conversion to ammonia is about 30%.

21 You are given the information below:

element	atomic number
W	11
X	12
Y	16
Z	17

Which of the following pairs of elements would react with each other most readily?

A ***W*** and ***Y***
B ***W*** and ***Z***
C ***X*** and ***Y***
D ***X*** and ***Z***

22 The atomic radius of some Group I elements of the Periodic Table is given.

element	atomic radius / pm
K	231
L	152
M	248
N	186

Which of the following shows the correct ascending order of melting point for the elements?

	lowest → highest			
A	***L***	***K***	***N***	***M***
B	***L***	***N***	***K***	***M***
C	***M***	***K***	***L***	***N***
D	***M***	***K***	***N***	***L***

23 The reaction between hydrogen and chlorine can be shown as $H_2 + Cl_2 \rightarrow 2HCl$.
Why is the reaction exothermic?

A The energy involved in the bonds breaking is greater than that of bonds forming.
B The energy involved in the bonds forming is greater than that of the bond breaking.
C The number of bonds broken is greater than the number of bonds formed.
D The number of bonds formed is greater than the number of bonds broken.

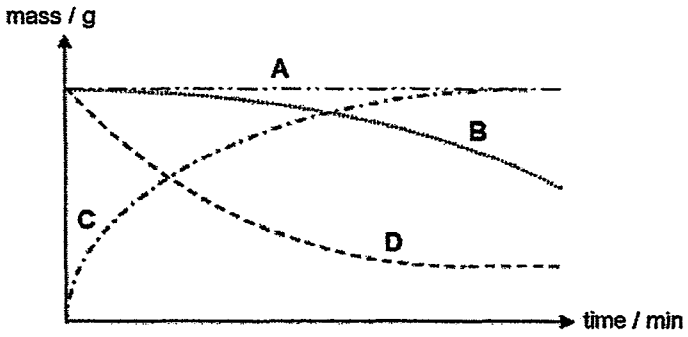
24 Which of the following reaction(s) are endothermic?

I $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$
II $Cl_2 \rightarrow 2Cl$
III $CuSO_4 + 5H_2O \rightarrow CuSO_4.5H_2O$
IV $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

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

25 In an experiment, a conical flask containing 50 cm^3 of hydrogen peroxide and 0.5 g of manganese(IV) oxide was placed on an electronic balance. The balance reading was recorded at regular time intervals. Hydrogen peroxide decomposes to form water and oxygen gas.

Which of the curves show the correct change in mass for this experiment?



26 In the testing of ions for qualitative analysis, which of the following ions undergo reduction?

A ammonium
B chloride
C nitrate
D sulfate

27 ***R*** is a solution of a reducing agent. It is added to each of the four reagents shown in the table below. Which of the following shows the correct description of the change in colour?

	reagent	effect of adding ***R***
A	acidified potassium manganate(VII)	purple to colourless
B	aqueous bromine	colourless to reddish-brown
C	aqueous chlorine	colourless to pale yellow
D	aqueous potassium iodide	colourless to brown

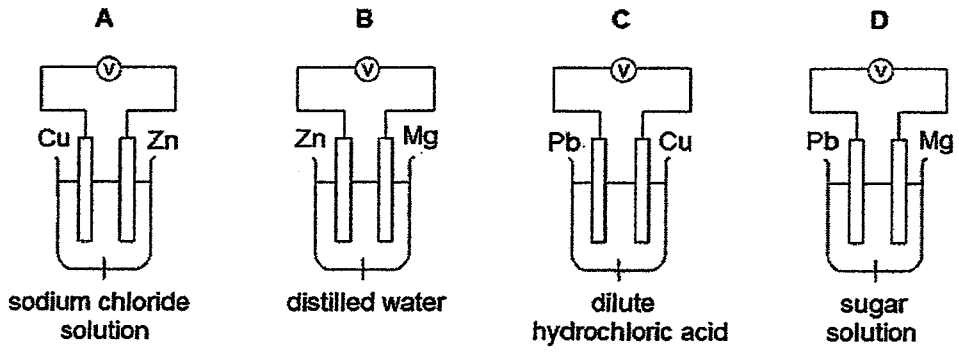
28 Which of the following gases **cannot** be removed from the exhaust of a petrol powered car by its catalytic converter?

A carbon dioxide
B carbon monoxide
C hydrocarbons
D nitrogen dioxide

29 In an electrolytic experiment involving aqueous silver nitrate, 1.08g of silver was deposited at the cathode. What is the volume of the gas collected at the anode?

A $30\ cm^3$
B $60\ cm^3$
C $180\ cm^3$
D $240\ cm^3$

30 Which of the set-ups will produce the greatest reading on the voltmeter?



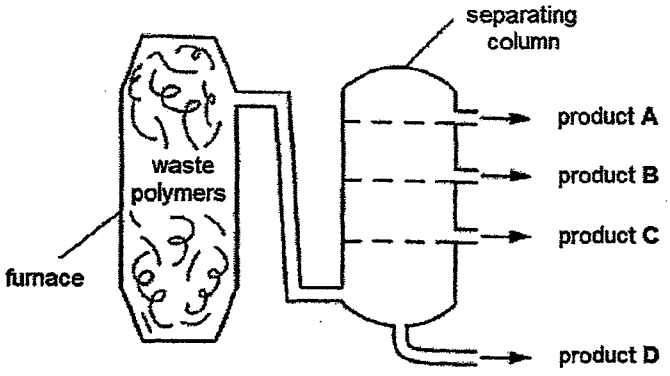
31 Pain is often felt when a piece of aluminium foil touches a dental amalgam filing in a tooth. The amalgam contains tin and an electric current momentarily flows. Which statement about what happens is **not** correct?

A The aluminium foil acts an oxidising agent.
B The current is smaller if a piece of zinc foil touches the tin amalgam.
C The electrons flow from aluminium foil to tin amalgam.
D The oxidation state of aluminium foil increases.

32 Which of the following is true about the formation of molten iron from haematite in the blast furnace?

A Coke is used as a catalyst for the process of forming molten iron.
B Haematite is made up of mainly iron(II) oxide.
C Limestone is used to remove alkaline impurities.
D Molten slag is collected above molten iron.

33 Waste polymers can be recycled by heating it in a furnace. The waste decomposes into a mixture of hydrocarbons which can be separated in a separating column.
Which product has the largest number of carbon atoms per molecule?



34 Which of the following is **not** true about the fractional distillation of crude oil?

A Bitumen fraction has the highest boiling point among the fractions.
B Kerosene fraction is used as fuel in aircraft.
C Naphtha fraction is used as feedstock for chemical industries.
D The different fractions obtained are pure.

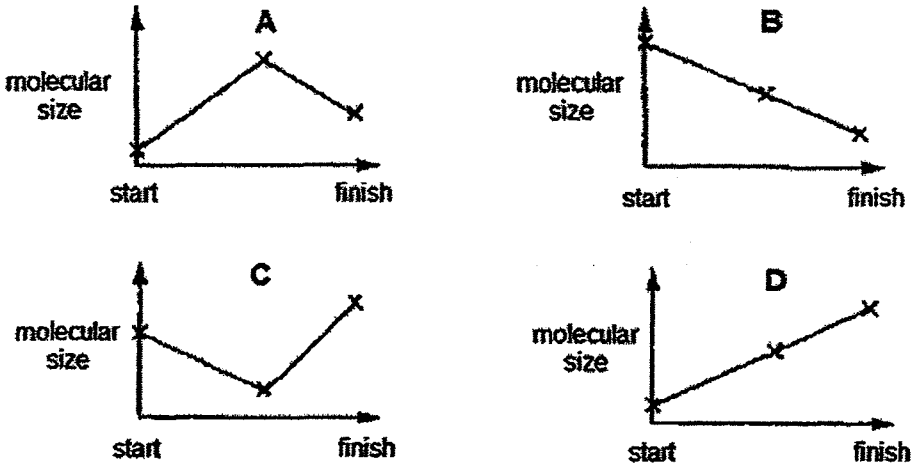
35 In the presence of sunlight, methane gas and chlorine gas are mixed together in an enclosed container. After two hours, which of the following is/are present in the container?

I CH_3Cl
II CCl_4
III HCl
IV H_2

A I and II
B I and III
C I, II and III
D All of the above

36 Poly(ethene) can be manufactured by the processes below.

Which diagram shows the correct change in molecular size during these processes?



37 When ethanol reacts with propanoic acid, the ester formed has the formula of

A $CH_3COOC_2H_5$
B $C_2H_5COOCH_3$
C CH_3COOCH_3
D $C_2H_5COOC_2H_5$

38 Which reagent **cannot** be used to distinguish methanol from methanoic acid?

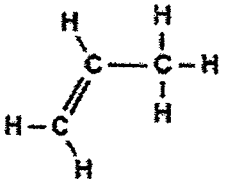
A acidified potassium manganate(VII)
B aqueous bromine
C aqueous sodium carbonate
D litmus solution

39 Linoleic acid has the molecular formula, $C_{17}H_{29}COOH$. How many C = C bonds are present in one molecule of linoleic acid?

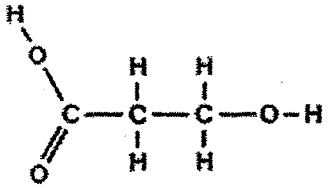
A 1
B 2
C 3
D 4

40 Which of the following monomer(s) would undergo polymerisation on their own?

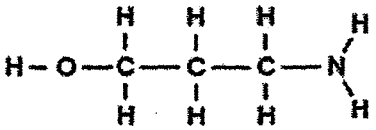
I



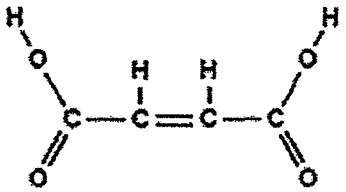
II



III



IV



A I, II and III
B I, II and IV
C II and III
D All of the above

GROUP

I	II											III	IV	V	VI	VII	0
							1 H Hydrogen 1										4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulphur 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 Rh Rhodium 45	96 Mo Molybdenum 42	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	Po Polonium 84	At Astatine 85	Rn Radon 86
Fr Francium 87	226 Ra Radium 88	Ac Actinium 89 †	Rf Rutherfordium 104	Db Dubnium 105	Sg Seaborgium 106	Bh Bohrium 107	Hs Hassium 108	Mt Meitnerium 109									

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

Key: a X b = a relative atomic mass; X atomic symbol; b proton (atomic) number

140 Ce Cerium 58	141 Pr Praseodymium 92	144 Nd Neodymium 60	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	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawencium 103

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

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Preliminary Examination 2016
Secondary Four Express & Five Normal

CANDIDATE NAME:

CLASS: / INDEX NUMBER:

CHEMISTRY 5073/02

Paper 2

24 August 2016

1 hour 45 minutes

1100 – 1245h

No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the Question Paper.

Section B
Answer all **three** questions, the last question is in the form either/or.
Write your answers in the spaces provided on the Question Paper.

The number of marks is given in brackets [ ] at the end of each questions
A copy of the Periodic Table is printed on page **23**.

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

Section A	
Section B	
Total	

Section A

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

A1 A list of solutions is given below.

$Ba(NO_3)_2$	$CuSO_4$	$FeSO_4$
HCl	NaOH	NH_4Cl

The solutions can be used once, more than once or not at all.

From the list, choose two solutions that will react to

(a) produce a blue precipitate,

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

(b) give a pungent gas,

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

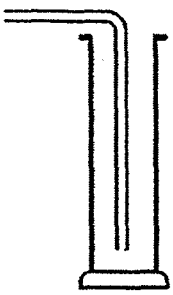
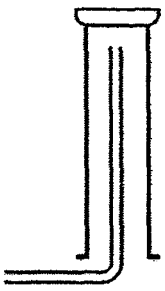
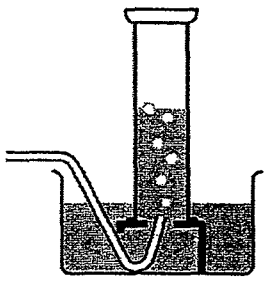
(c) produce a white precipitate in a green solution.

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

[total: 3]

A2 Ammonia gas is an important starting material in the manufacture of fertilisers and many commercial cleaning products.

Three different methods of collecting gases in the laboratory are shown below.

method **1**	method **2**	method **3**
		

(a) Which of the methods is the most suitable for the collection of ammonia gas in the laboratory? Give reasons to support your answer by stating why the other methods are **not** suitable.

.....

.....

..... [2]

(b) In the industry, ammonia gas is produced by the Haber process. State the optimum conditions used in this process.

.....

..... [2]

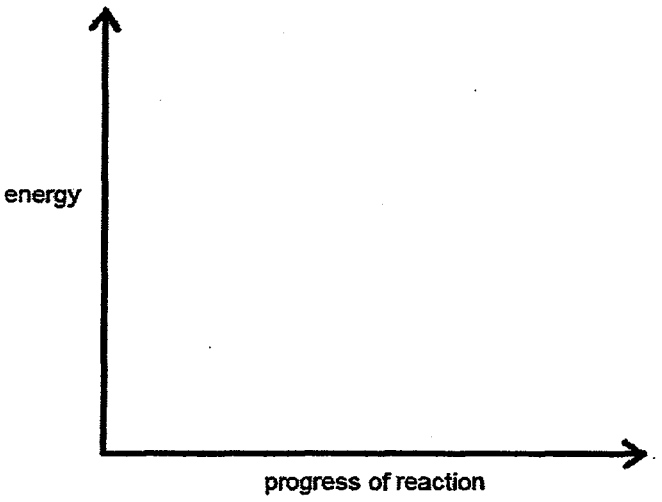
(c) Ammonium nitrate is predominantly used in agriculture as a fertiliser. When ammonium nitrate is added to water, the reaction mixture feels cold.

The reaction between solid ammonium nitrate and water can be represented as:

$$NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$$

Draw an energy profile diagram for the reaction between ammonium nitrate and water below. On the diagram, you should label the

- activation energy, E_a
- energy change for the reaction, ΔH. [3]

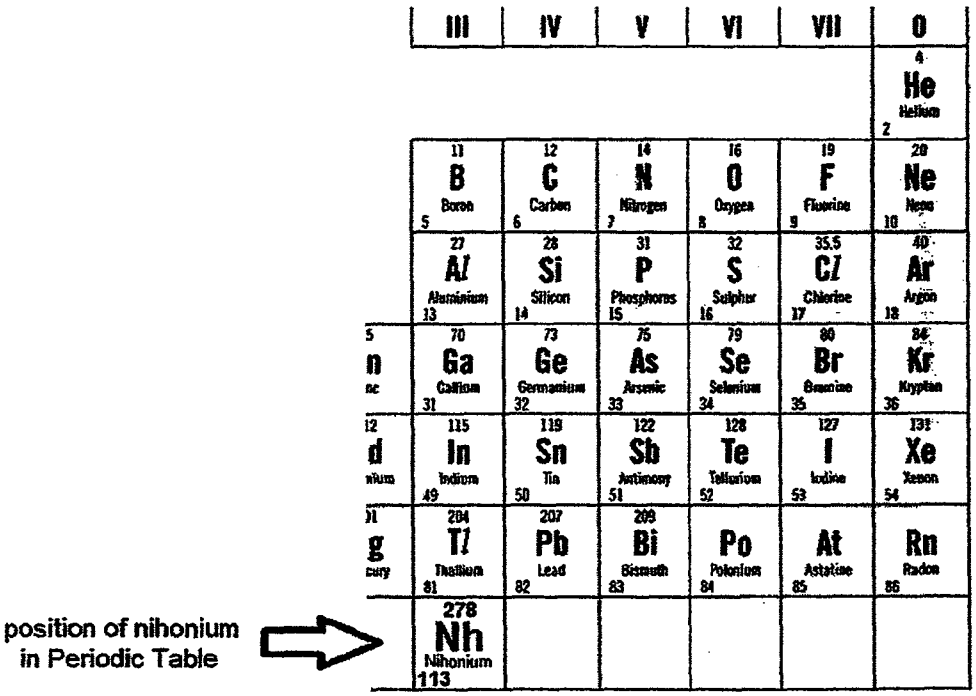


[total: 7]

A3 Recently, the International Union of Pure and Applied Chemistry (IUPAC) has announced the proposed names for the four newest elements to be added in Period 7 of the Periodic Table.

One of the new element, with atomic number 113, the first to be discovered in an Asian country, has been christened nihonium (Nh), which borrowed its name from one of the Japanese names for Japan - nihon.

The position of nihonium in the Periodic Table is shown below.



The element was discovered by Japan's Riken Institute by colliding a thin layer of bismuth with zinc as shown in the equation below.

$$^{209}_{83}Bi + {}^{70}_{30}Zn \rightarrow {}^{278}_{113}Nh + particle\ X$$

(a) Name particle ***X***, a by-product in the synthesis of nihonium.

.....[1]

(b) Nihonium exists as three isotopes, nihonium-278, nihonium-282 and nihonium-285. Describe with examples, one similarity and one difference in the properties of three samples of nihonium containing nihonium-278, nihonium-282 and nihonium-285 respectively. You may refer to the samples as nihonium-278, nihonium-282 and nihonium-285 in your answers.

.....

.....

.....

.....

.....

..... [3]

(c) Another new element, with atomic number 117, to be named as tennessine (with symbol Ts) will be placed close to nihonium in the Period Table.

(i) In which group of the Periodic Table would you expect tennessine to be found?

..... [1]

(ii) A student made a few predictions about tennessine. Put a tick (√), in each of the correct boxes to show which of the following predictions about the properties of tennessine are true and which are false. [2]

	true	false
Tennessine is a good conductor of electricity.		
Tennessine is a solid at room conditions.		
Tennessine is green in colour.		
Tennessine is the most reactive element in its group in the Periodic Table.		

[total: 7]

A4 An oxyacid is an acid that contains an oxygen atom bonded to a hydrogen atom and at least one other element. Sulfuric acid (H_2SO_4), phosphoric acid (H_3PO_4) and nitric acid (HNO_3) are all oxyacids.

Chlorine forms several types of oxyacids. The table below shows some properties of oxyacids of chlorine.

name of acid	chemical formula	reaction with magnesium (all acids have the same concentration)	oxidation state of chlorine
perchloric acid	$HClO_4$	very vigorous	
hypochlorous acid	HOCl	only a few bubbles seen	
chloric acid	$HClO_3$	vigorous	+5
chlorous acid	$HClO_2$	reacts readily	+3

(a) Complete the table by filling in the oxidation state of chlorine. [2]

(b) **(i)** Arrange in ascending order the strength of these acids, starting with the weakest acid.

..... [1]

(ii) Hence, deduce the trend in the strength of the acid with reference to the information in the table.

..... [1]

(c) Hypochlorous acid (HOCl) can be made from dichlorine monoxide gas (Cl_2O). Draw a 'dot-and-cross' diagram to show the bonding in dichlorine monoxide. Show the outer electrons only. [2]

(d) Hypochlorous acid (HOCl) can also be produced by reacting chlorine with water.

$$Cl_2 + H_2O \rightarrow HOCl + HCl$$

Explain, in terms of oxidation states, why the reaction shown above is a redox reaction.

.....

.....

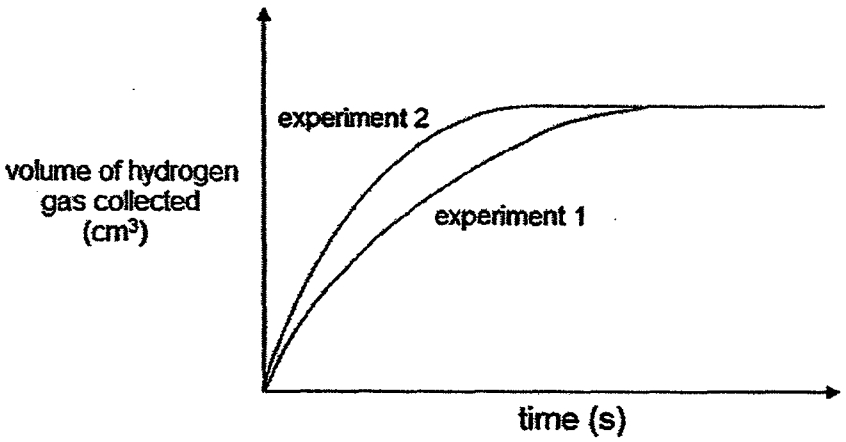
..... [2]

[total: 8]

A5 A student carried out two experiments involving the reaction between zinc and dilute hydrochloric acid. Information about the experiments is given in the table below.

	experiment **1**	experiment **2**
granulated zinc	excess	excess
dilute hydrochloric acid	5.0 cm^3, 1.0 mol/dm^3	5.0 cm^3, 1.0 mol/dm^3
temperature	25°C	25°C
copper(II) sulfate solution	not added	added a few drops

The results of the experiments are shown in the graph.



(a) **(i)** Which experiment has a faster rate of reaction? How do you know?

.....[1]

(ii) Suggest why this happens.

.....

.....[1]

(b) Write a balanced chemical equation for the reactions in both experiments.

.....[1]

(c) For both experiments, zinc is used in excess. Calculate the mass of zinc that reacted. [2]

(d) Two other experiments were performed using the following conditions. Sketch the curves using the same axes (on the previous page) to show the results of the experiments. Label your curves clearly as experiment **3** and experiment **4**. [2]

	experiment **3**	experiment **4**
granulated zinc	excess	excess
dilute hydrochloric acid	5.0 cm^3, 0.5 mol/dm^3	5.0 cm^3, 1.0 mol/dm^3
temperature	25°C	40°C
copper(II) sulfate solution	not added	added a few drops

(e) Experiment **5** was performed under the same conditions as experiment **1** but dilute sulfuric acid (5.0 cm^3 and 1.0 mol/dm^3) was added instead of dilute hydrochloric acid to zinc. The rate of reaction in experiment **5** was found to be faster than experiment **1**. Use ideas about collisions between particles to explain this observation.

.....

.....

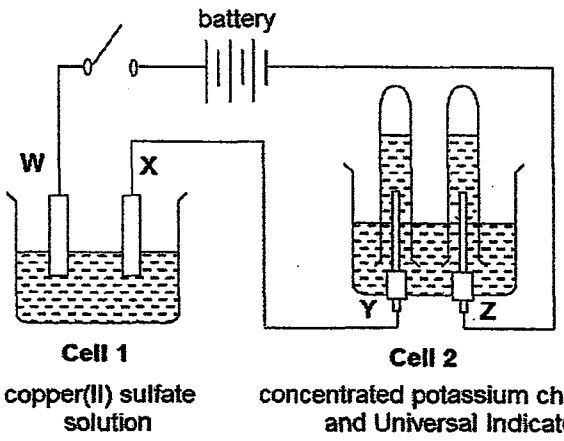
.....

.....

..... [2]

[total: 9]

A6 An electric circuit is set up as shown below.



Electrodes ***W*** and ***X*** are made of copper while electrodes ***Y*** and ***Z*** are made of carbon. The switch is closed and some changes are observed.

(a) **(i)** State one visible change that can be observed in **Cell 1**.

..... [1]

(ii) Write the ionic half-equations for the reactions at the cathode and anode respectively in **Cell 1**. Hence, state with a reason whether there will be any change in the colour intensity of the copper(II) sulfate solution throughout the experiment in this cell.

.....

.....

.....

..... [3]

(b) **(i)** Describe the colour change of the Universal Indicator during electrolysis of the concentrated potassium chloride solution in **Cell 2**.

..... [1]

(ii) Explain your observation in (b)(i).

.....

..... [2]

[total: 7]

A7 This article was adapted from The Straits Times dated June 11, 2016.

'Scientists find way to lock away carbon dioxide.'

Scientists say they may have found a radical breakthrough to tackling climate change - by pumping heat-trapping carbon dioxide gas into the ground and turning it into stone.

The research, called the *CarbFix* project and led by Columbia University, was published in American journal *Science* on Thursday (June 9).

The approach involves dissolving carbon dioxide gas with water and pumping the resulting mixture - essentially, soda water - down into certain kinds of rocks, where the carbon dioxide gas reacts with the rock to form a mineral stone called *calcite. By turning the carbon dioxide gas into calcite, scientists can then lock it away permanently.

**calcite has the chemical formula of $CaCO_3$*

One key to the approach is to find the right kind of rocks. Volcanic rocks called basalts are excellent for the process, because basalts are rich in calcium, which react with carbon dioxide gas.

The research was conducted for years in Iceland, a volcanic island made up mainly of basalt. Scientists found that the conversion yield is about 95 %; meaning that 95% of the carbon dioxide was converted into calcite. More importantly, the conversion happened relatively quickly - in less than two years, instead of ten years as previously predicted by scientists using computer.

(a) Explain the importance of the CarbFix project in protecting the environment.

.....

.....

.....

.....

..... [2]

(b) Other than calcite, name another mineral that also contain $CaCO_3$.

..... [1]

(c) 'Soda water' mentioned in the article is actually weak carbonic acid. Explain what is meant by the term *weak acid*.

.....

..... [1]

(d) A researcher in the *CarbFix* project decided to investigate the presence of calcium ions in calcite. He was given the following four reagents:

dilute sulfuric acid	dilute hydrochloric acid
aqueous ammonia	aqueous sodium hydroxide

Describe the tests that he should carry out. Your answer should include

- the reactions involved using some of the given reagents,
- how the observations showed the presence of calcium ions in calcite.

.....

.....

.....

.....

..... [3]

(e) Suggest a reason why

(i) the conversion of carbon dioxide gas into calcite happened relatively quickly in Iceland.

.....

..... [1]

(ii) conversion yield of carbon dioxide gas into calcite may not reach 100%.

.....

..... [1]

[total: 9]

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.

B8 Transition metals are found in the central block of the Periodic Table.
Table 1 shows part of the central block of the Periodic Table which displays transition metals found in Periods 4, 5 and 6. The proton numbers of each of the metals are included as well.

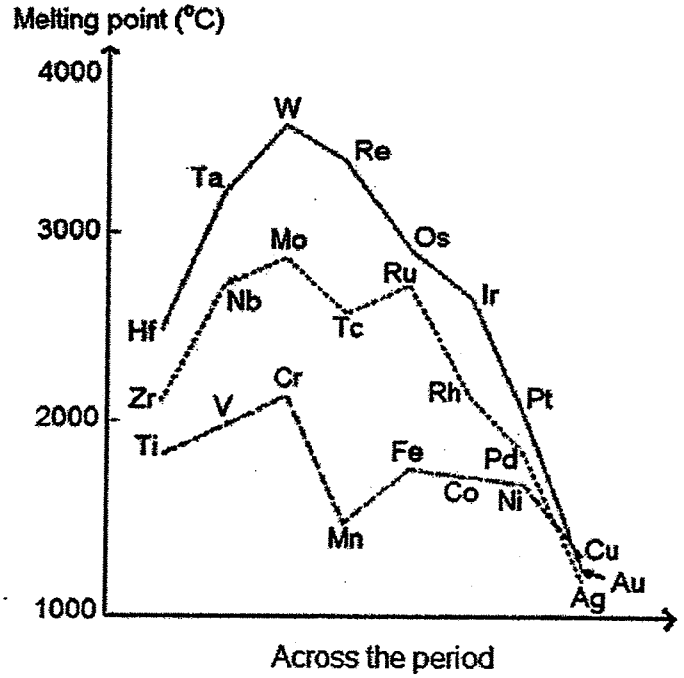
Table 1

across the period →

down the group ↓

Period	transition metals							
4	$_{22}Ti$	$_{23}V$	$_{24}Cr$	$_{25}Mn$	$_{26}Fe$	$_{27}Co$	$_{28}Ni$	$_{29}Cu$
5	$_{40}Zr$	$_{41}Nb$	$_{42}Mo$	$_{43}Tc$	$_{44}Ru$	$_{45}Rh$	$_{46}Pd$	$_{47}Ag$
6	$_{72}Hf$	$_{73}Ta$	$_{74}W$	$_{75}Re$	$_{76}Os$	$_{77}Ir$	$_{78}Pt$	$_{79}Au$

The graph below shows the melting points of the transition metals of those listed in **Table 1**.



(a) Use the information above to describe the trends in melting point of transition metals

(i) down the groups,

..... [1]

(ii) across the periods.

.....

.....

.....

..... [2]

(b) How does the information show that the transition metals in Period 4 are solids at room temperature and pressure?

.....

..... [1]

(c) In an experiment to determine the relative reactivity of five transition metals (Cr, Cu, Au, Fe and Ag), small pieces of each metal were added to the aqueous nitrate solutions of the other metals. **Table 2** shows the results.

Key

√	shows a reaction happened
×	shows no reaction happened
-	shows the experiment was not performed

Table 2

	chromium (Cr)	copper (Cu)	gold (Au)	iron (Fe)	silver (Ag)
chromium nitrate solution	-	×	×	×	×
copper(II) nitrate solution	√	-	×	√	×
gold nitrate solution	√	√	-	√	√
iron(III) nitrate solution	√	×	×	-	×
silver nitrate solution	√	√	×	√	-

(i) Place the metals in the descending order of reactivity, starting with the most reactive.

..... [2]

(ii) Write an ionic equation, for the reaction between copper and silver nitrate solution.

..... [1]

(d) With reference to your answer in (c)(i) and the information from the **Table 1**, deduce the trend of the reactivity of transition metals

(i) across the periods, ... [1]

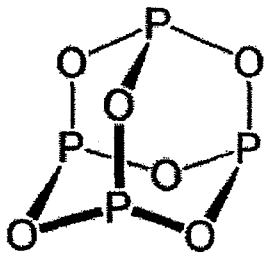
(ii) down the groups. ..... [1]

(e) From **Table 1**, name the metal that is most likely to displace **only** eight other metals from their salt solutions.

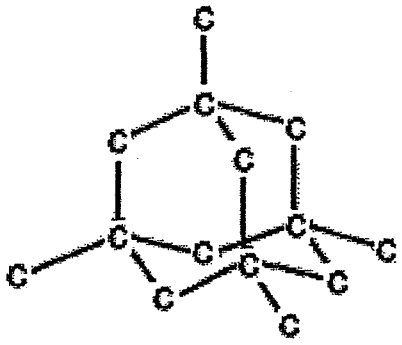
..... [1]

[total: 10]

B9 The structures of phosphorus trioxide and diamond are shown below.



phosphorus trioxide



diamond

(a) Write down the molecular formula of phosphorus trioxide.

..... [1]

(b) Based on the diagrams above, explain how it could be deduced that the structure shown for phosphorus trioxide is that of a simple molecule, while that of diamond represents only part of a macromolecule.

.....

.....

.....

.....

.....

.....

..... [4]

(c) Explain why the melting points of phosphorus trioxide and diamond is different.

.....

.....

..... [2]

(d) An oxide was found to have the following composition by mass.

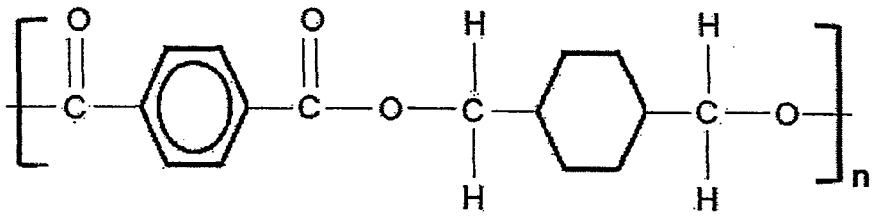
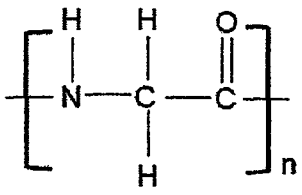
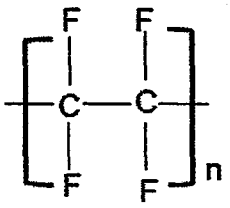
element	percentage by mass
phosphorus	43.7
oxygen	56.3

Deduce whether this oxide could be phosphorus trioxide by determining its empirical formula. [3]

[total: 10]

EITHER

B10 The table below shows some information regarding three polymers – Kodel©, polyglycine and Teflon©.

name	structure
Kodel©	
polyglycine	
Teflon©	

(a) Draw and name the linkage found in polyglycine. [2]

(b) Draw the structures of the two monomers used to form Kodel©. [2]

(c) Draw the structure of the monomer used to form Teflon©. [1]

(d) The monomer shown in (c) can react with chlorine gas to form a compound that can be classified as chlorofluorocarbon (CFC).

(i) Write an equation for the reaction between the monomer of Teflon© and chlorine gas.

..... [1]

(ii) Explain how CFCs cause ozone depletion in the upper atmosphere.

.....

.....

..... [2]

(e) Kodel© polymers are formed in a different way from Teflon© polymers. Name both types of polymerisation involved and state one difference between them.

.....

.....

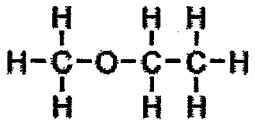
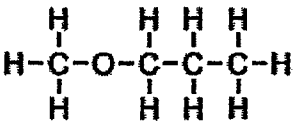
..... [2]

[total: 10]

OR

B10 This question concerns the chemistry of some organic compounds.

(a) The table shows some information about the homologous series of a class of organic compounds called ethers.

name	molecular formula	structural formula
methoxy ethane	$CH_3OC_2H_5$	
methoxy propane	$CH_3OC_3H_7$	

(i) Give the name and structural formula of the next member of this homologous series. [2]

name: .....

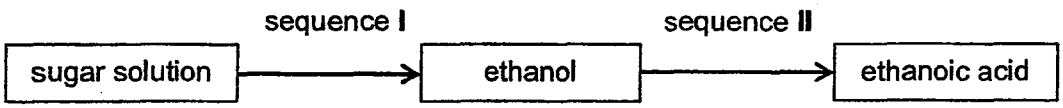
structural formula:

(ii) Draw the full structural formula of two isomers of methoxy ethane. [2]

(b) Ethanoic acid can be synthesised by using various methods.
In method **1**, ethanoic acid is synthesised from methanol as shown by the following reaction sequence:

sequence	reaction
I	$CH_3OH + HCl \rightarrow CH_3Cl + H_2O$
II	$CH_3Cl + CO \rightarrow CH_3COCl$
III	$CH_3COCl + H_2O \rightarrow CH_3COOH + HCl$

In method **2**, ethanoic acid is synthesised from sugar as shown by the following reaction sequence:



(i) Name the type of reaction as shown in reaction sequence **I** in method **1**.

..... [1]

(ii) For method **2**, state the optimum conditions needed for reaction sequence **I**.

.....

..... [2]

(iii) For method **2**, name the reagent used for reaction sequence **II** in the laboratory.

..... [1]

(iv) In the industry, which method provides a safer working environment?
Suggest one reason to support your answer.

.....

..... [1]

(v) Chloromethane (CH_3Cl) can be produced from an alkane.
Write an equation to show this reaction.

..... [1]

[total: 10]

GROUP

I	II											III	IV	V	VI	VII	0
							1 H Hydrogen 1										4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulphur 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 Rh Rhodium 45	96 Mo Molybdenum 42	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	Po Polonium 84	At Astatine 85	Rn Radon 86
Fr Francium 87	226 Ra Radium 88	Ac Actinium 89 †	Rf Rutherfordium 104	Db Dubnium 105	Sg Seaborgium 106	Bh Bohrium 107	Hs Hassium 108	Mt Meitnerium 109									

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

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	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	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

Key: a X b — a = relative atomic mass; X = atomic symbol; b = proton (atomic) number

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

Answer Scheme for Chemistry 5073 Prelims 2016

Paper 1 [40 marks]

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

Paper 2 Section A [50 marks]

A1 (a) $CuSO_4$ and NaOH

(b) NaOH and NH_4Cl

(c) $Ba(NO_3)_2$ and $FeSO_4$

A2 (a) Method 2.

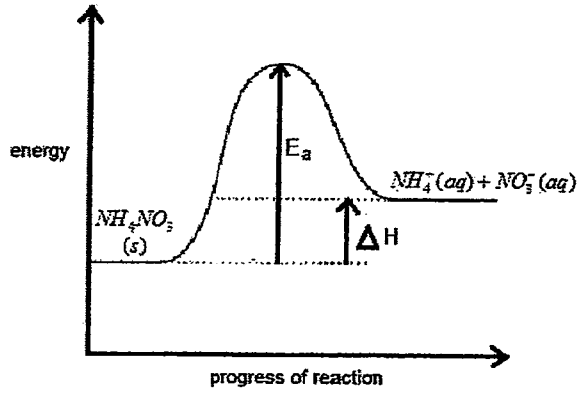
Ammonia gas is soluble in water, thus method 3 cannot be used.

Ammonia gas is less dense than air, thus method 1 cannot be used.

(b) 250 atm and 450 °C.

Iron as catalyst.

(c) *Refer to diagram below for marking scheme*



A3 (a) neutron

(b) All three elements will have the same chemical reactions (properties) but different physical properties.

Give one example in same chemical property such as all elements will react with chlorine to form ionic compounds.

Give one example in different physical property such as density. Nihonium-285 will has the highest density followed by nihonium-282 and nihonium-278.

(ci) group VII

(cii) Refer to table below.

	True	False
Tennessine is a good conductor of electricity.		√
Tennessine is a solid at room conditions.	√	
Tennessine is green in colour.		√
Tennessine is the most reactive element in its group in the Periodic Table.		√

A4 (a) +7 and +1

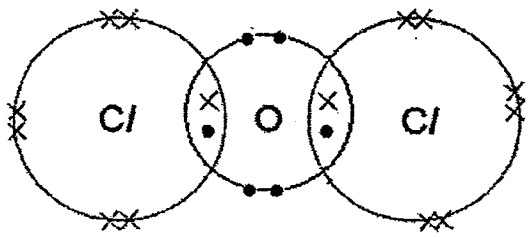
(bi) HOCl, $HClO_2$, $HClO_3$, $HClO_4$

OR hypochlorous acid, chlorous acid, chloric acid, perchloric acid

(bii) As the oxidation state of chlorine in the acid increases, the strength of the acid increases too. OR

As the number of oxygen per molecule/in the formula in the acid increases, the strength of the acid increases too.

(c) *Draw dichlorine monoxide correctly as shown below with legend*



(d) Cl_2 is reduced (OR reduction occurs) since the oxidation state of Cl decreases from 0 in Cl_2 to -1 in HCl.

Cl_2 is oxidised (OR oxidation occurs) since the oxidation state of Cl increases from 0 in Cl_2 to +1 in HOCl.

Since both oxidation and reduction occur, this is a redox reaction.

A5 (ai) Experiment 2. It has a steeper gradient (at the start of the experiment).

(aii) Copper(II) sulfate was added to speed up the rate of reaction of experiment 2.

(b) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

(c) number of mole of HCl used $= \frac{5}{1000} \times 1$

$= 0.005$

Based on the equation, number of mole of Zn reacted

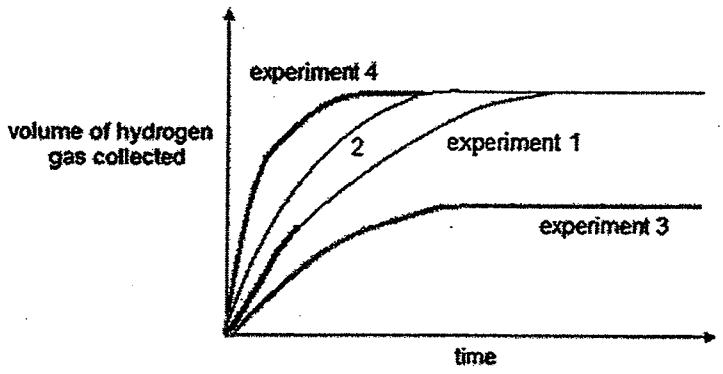
$= 0.005 \div 2$

$= 0.0025$

Thus, the mass of zinc reacted $= 0.0025 \times 65$

$= 0.163$ g

(d) *Refer to the diagram below for marking scheme*



(e) Sulfuric acid is dibasic while hydrochloric acid is monobasic.
Thus, the concentration of H^+ ions in sulfuric acid is twice of that of hydrochloric acid.
With a higher concentration, the reacting particles in experiment 5 will collide more frequently as compared to experiment 1.
As a result, there will be higher number of effective collisions per unit time in experiment 5, leading to a higher rate of reaction.

A6 (ai) Electrode W diminishes in size. OR

Electrode X is coated with a layer of pinkish brown / brown deposit.

OR Electrode X increases in size.

(aii) At anode: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e$

At cathode: $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$

Since there is no change in the concentration of Cu^{2+} / copper(II) ions, the colour intensity remained in cell 1.

(bi) From green to violet.

(bii) At anode / Y, the Cl^- ions is oxidised while at cathode / Z, the H^+ is reduced. OR

At anode / Y, the Cl^- ions lose electrons while at cathode / Z, the H^+ gain electrons.

Thus, the concentration of OH^- is much higher than the concentration of H^+ ions making the solution turned strongly alkaline [1], resulting in the violet colour.

OR

K^+ and OH^- ions are left behind / KOH solution is formed, resulting in a strong alkaline solution, making the solution turns violet.

A7 (a) CarbFix aims to reduce the amount of carbon dioxide in the atmosphere. By doing so, the effect of global warming can be reduced.

Carbon dioxide causes global warming which results in ... → *Accept one of the following effects stated below.*

... melting of polar ice caps that causes sea level to rise. As a result, low-lying land will be flooded. /

... prolong drought that turns vegetation area into deserts. As a result, crops will be reduced. /

... rapid evaporation of seawater that lead to more carbon dioxide being released into the atmosphere. As a result, earth's average temperature will rise further.

(b) limestone

(c) Weak acid refers to a substance that partially dissociates to form hydrogen ions when dissolved in water.

(d) Add dilute hydrochloric acid to calcite to form calcium chloride solution.

Next, add calcium chloride solution to aqueous sodium hydroxide.

White precipitate formed that is insoluble in excess aqueous sodium hydroxide will show the presence of calcium ions.

(ei) The high temperature due to the volcanoes around Iceland causes the speed of reaction / conversion to increase.

(eii) The calcite decomposes due to heating / high temperature. Thus, 100% conversion may not be achievable.

Paper 1 Section B [30 marks]

Section B

B8 (ai) Generally, down the groups, the melting point of metals increases except for the elements in the last group / except for metals Cu, Au and Ag.

(aii) Across all periods, the melting point increases for the first three metals (elements) listed before it shows a decreasing trend for the next few metals.

However, for periods 4 and 5, the 4th element has a lower melting point than expected.

(b) The melting points of the metals are at least 1000°C, much higher than room temperature.

(ci) Cr, Fe, Cu, Ag, Au

(cii) $Cu(s) + 2Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$

(di) *across the period:* decreases

(dii) *down the period:* decreases

(e) cobalt

B9 (a) P_4O_6

(b) For the phosphorus trioxide, every / all atom(s) formed the number of bonds required to achieve stable octet electronic configurations.

As shown, oxygen atoms and phosphorus atoms formed two and three covalent bonds respectively.

Carbon atoms need to form four covalent bonds to achieve stable octet electronic configurations.

For diamond, some of the carbon atoms have only formed either one or two covalent bonds / formed less than four covalent bonds.

(c) Phosphorus trioxide has a low melting point while diamond has a very high melting point.

A small amount of energy is needed to overcome the weak intermolecular forces between the molecules in phosphorus trioxide.

A very large amount of energy is needed to break all the strong covalent bonds between the (very large number of) atoms in the structure.

(d)

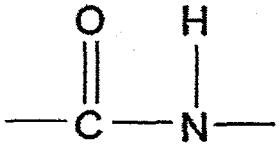
element	P	O
mass (g) / % by mass	43.7	56.3
number of moles	$\frac{43.7}{31} = 1.409$	$\frac{56.3}{16} = 3.518$
molar ratio	$\frac{1.409}{1.409} = 1$	$\frac{3.518}{1.409} \approx 2.5$
simplest ratio	2	5
empirical formula	P_2O_5	

Since the empirical formula of phosphorus trioxide is P_2O_3, not P_2O_5, this oxide cannot be phosphorus trioxide.

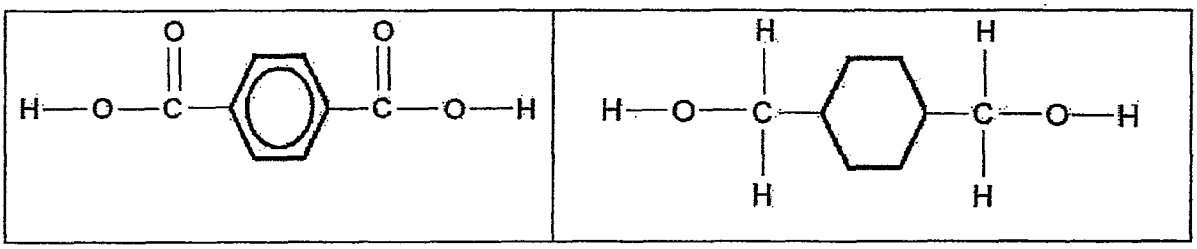
B10 Either

(a) Name of linkage: amide

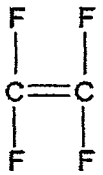
Draw structure of linkage as shown below.



(b) *Draw the monomers as shown below.*



(c) *Draw the monomer as shown below.*



(di) $C_2F_4 + Cl_2 \rightarrow C_2F_4Cl_2$

(dii) In the upper atmosphere, CFCs decomposes under ultra-violet radiation to form chlorine atoms.

The chlorine atoms react with ozone molecules to form oxygen gas and chlorine monoxide, thus causing ozone depletion.

(e) For Kodel©, it is condensation polymerisation and for Teflon©, it is addition polymerisation.

For differences, accept one of the followings or any other possible answers.

For addition, no by-product is formed / only Teflon© polymers is formed while in condensation, by-product which is a small (or simple) molecule is formed.

OR

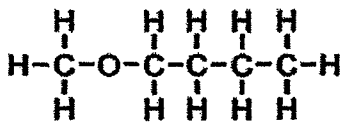
The formation of addition polymers does not involve the loss of atoms / loss of materials while in the formation of condensation polymers, small (or simple) molecule is lost. OR

The two different monomers used in condensation polymers / Kodel© have different functional groups of carboxyl and hydroxyl respectively. The monomer used in addition polymers / Teflon© has the functional group of carbon-carbon double bond.

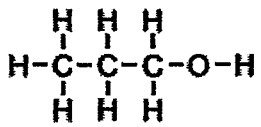
B10 OR

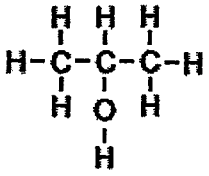
(ai) methoxy butane

Draw the structure as shown below.



(aii) *Draw the isomers as shown below.*





(bi) substitution

(bii) presence of yeast

absence of oxygen

temperature of 37°C

(biii) acidified potassium manganate (VII)

(biv) Method 2 is safer since in method 1, carbon monoxide, a poisonous gas is used. OR

Method 2 is safer since in method 1, hydrogen chloride, a poisonous / acidic gas is used/produced.

(bv) $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$