

Name: _____ ()

Class: _____

SECONDARY 4 O LEVEL
PRELIMINARY EXAMINATION 2016

CHEMISTRY 5073

Paper 1

31 August 2016

1 hour

READ THESE INSTRUCTIONS FIRST

Write your name, register number, and class on the OAS sheet using a **soft pencil**.

There are **forty** questions in this paper.

Answer **all** questions.

For each question there are four possible answers **A, B, C** and **D**.

Choose the **correct** answer and record the corresponding letter using a **soft pencil** on the OAS sheet.

Amendments may be done using a soft eraser.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

A calculator may be used.

A copy of Periodic Table is provided on page 2.

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 is 40.

| | |
|---------------------------|--|
| For Examiner's Use | |
| Total (40) | |

The Periodic Table of the Elements

| | | Group | | | | | | | | | | | | | | |
|----------------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|------------------------------|------------------------------|------------------------------|-----------------------------|----------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|-----------------------------|--------------------------|
| I | II | III | IV | V | VI | VII | 0 | | | | | | | | | |
| 7 Li lithium 3 | 9 Be beryllium 4 | 11 B boron 5 | 12 C carbon 6 | 14 N nitrogen 7 | 16 O oxygen 8 | 19 F fluorine 9 | 20 Ne neon 10 | | | | | | 4 He helium 2 | | | |
| 23 Na sodium 11 | 24 Mg magnesium 12 | 27 Al aluminium 13 | 28 Si silicon 14 | 31 P phosphorus 15 | 32 S sulfur 16 | 35.5 Cl chlorine 17 | 40 Ar argon 18 | | | | | | | | | |
| 39 K potassium 19 | 40 Ca calcium 20 | 45 Sc scandium 21 | 48 Ti titanium 22 | 55 Mn manganese 25 | 58 Co cobalt 27 | 59 Ni nickel 28 | 64 Cu copper 29 | 70 Zn zinc 30 | 73 Ga gallium 31 | 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 | 96 Mo molybdenum 42 | 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 | 127 I iodine 53 | 131 Xe xenon 54 | | |
| 133 Cs cesium 55 | 137 Ba barium 56 | 139 La lanthanum 57 | 142 Hf hafnium 72 | 181 Ta tantalum 73 | 184 W tungsten 74 | 186 Re rhenium 75 | 192 Os osmium 76 | 195 Pt platinum 78 | 197 Au gold 79 | 201 Hg mercury 80 | 204 Tl thallium 81 | 207 Pb lead 82 | 209 Bi bismuth 83 | 210 Po polonium 84 | 210 At astatine 85 | 210 Rn radon 86 |
| 87 Fr francium | 88 Ra radium | 89 Ac actinium | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|----------------------------|---------------------------------|------------------------------|------------------------------|-------------------------------|------------------------------|-------------------------------|------------------------------|--------------------------------|--------------------------------|------------------------------|---------------------------------|------------------------------|--------------------------------|
| 140 Ce cerium 58 | 141 Pr praseodymium 59 | 144 Nd neodymium 60 | 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 | 238 Pa protactinium 91 | 238 U uranium 92 | 238 Np neptunium 93 | 238 Pu plutonium 94 | 238 Am americium 95 | 238 Cm curium 96 | 238 Bk berkelium 97 | 238 Cf californium 98 | 238 Es einsteinium 99 | 238 Fm fermium 100 | 238 Md mendelevium 101 | 238 No nobelium 102 | 238 Lr lawrencium 103 |

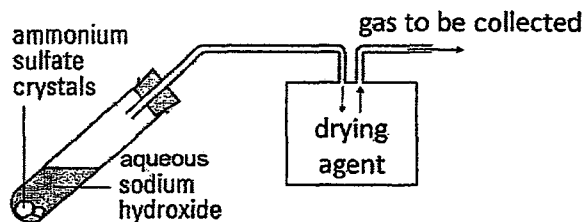
*58-71 Lanthanoid series
†90-103 Actinoid series

Key

| | | |
|---|---|---|
| a | X | b |
| | | |

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

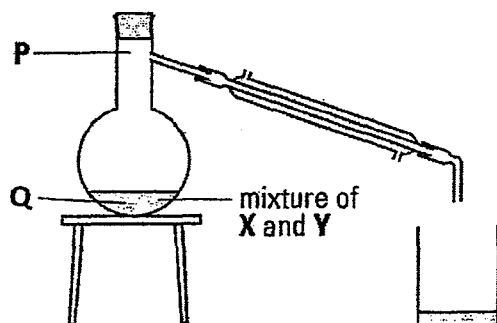
- 1 An excess of aqueous sodium hydroxide was added to a sample of ammonium sulfate crystals. The mixture was then heated gently, and the gas evolved was dried and collected using a suitable method.



What is the most suitable drying agent and gas collection method for the gas evolved?

| | Drying agent | Gas collection method |
|---|----------------------------|-----------------------|
| A | Anhydrous calcium chloride | Water displacement |
| B | Concentrated sulfuric acid | Downward delivery |
| C | Anhydrous calcium chloride | Upward delivery |
| D | Concentrated sulfuric acid | Upward delivery |

- 2 The diagram below shows the partial set-up of a simple distillation experiment used to separate two substances, X (boiling point of 70°C) and Y which is soluble in X (boiling point of 535°C).

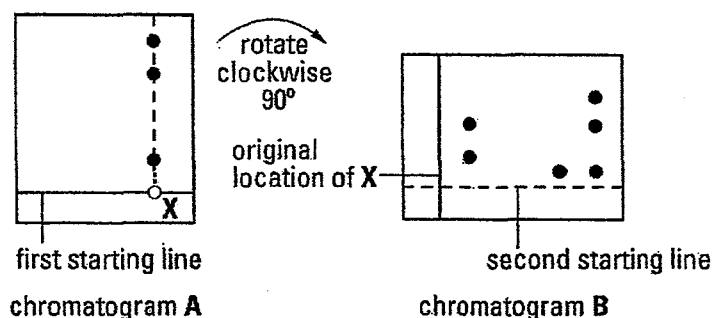


At which position, P or Q, should the bulb of a thermometer be placed at and what temperature should the thermometer show when the first distillate is collected.

- A At P and at 70°C
 B At P and at 535°C
 C At Q and at 70°C
 D At Q and at 535°C

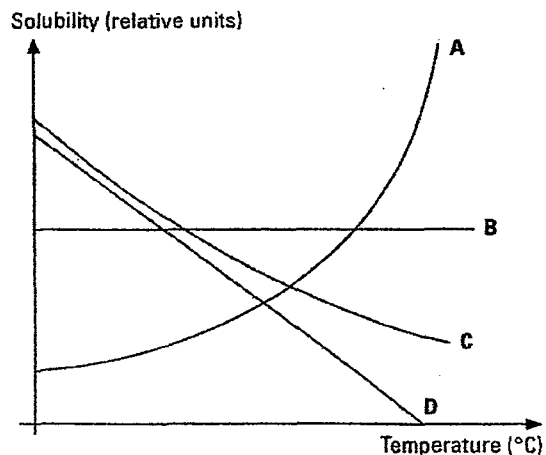
- 3 An experiment was carried out to determine the different types of sugar present in a sample of mixture X.

Chromatogram A shows the separation of sugars using water as a solvent. Chromatogram A is then removed, rotated clockwise and then placed inside another solvent, ethanol. The final results are shown in chromatogram B.



How many different types of sugars are present in mixture X?

- A 3
 B 4
 C 5
 D 6
- 4 The solubility curves of four different substances A to D in water are shown below:

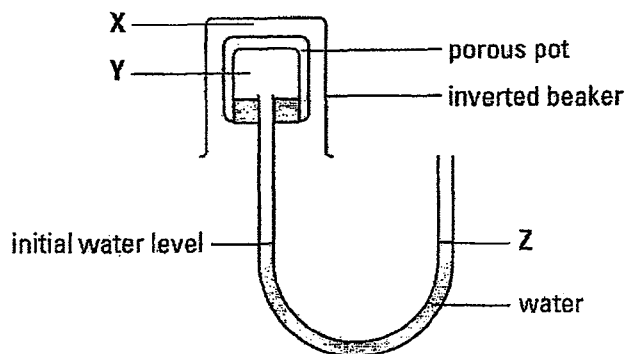


Which substance is the most suitable to be collected by crystallization from its hot saturated aqueous solution?

- 5 Which of the following best describes the arrangement of particles present in dilute aqueous ammonia?

| | NH_3 molecules | OH^- ions |
|---|-------------------------|--------------------|
| A | Not present | Close together |
| B | Not present | Far apart |
| C | Close together | Close together |
| D | Far apart | Far apart |

- 6 The diagram below is a set up involving two gases X and Y.



After some time, the water level at Z rises. What could be the identities of gas X and Y?

| | X | Y |
|---|----------------|------------------|
| A | Fluorine | Neon |
| B | Ethane | Nitrogen dioxide |
| C | Air | Methane |
| D | Sulfur dioxide | Propene |

- 7 The melting and boiling points of three substances are given below.

| Substance | Melting point/ °C | Boiling point/ °C |
|-----------|-------------------|-------------------|
| Argon | -189 | -186 |
| Nitrogen | -210 | -196 |
| Oxygen | -218 | -183 |

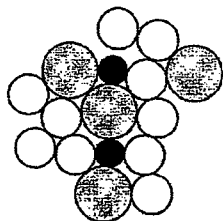
At what temperature would one of the above substances exist as a solid, another one as a liquid and the third as a gas?

- A -184°C
 B -188°C
 C -192°C
 D -214°C

8 Which of the following pairs consists of two mixtures?

- A Petrol and air
- B Sugar and bronze
- C Steel and hydrogen chloride
- D Petroleum and sulfur dioxide

9 The diagram below shows the structure of a substance.



Which of the following statements about the substance is true?

- A The substance is a compound.
 - B The substance melts over a range of temperature.
 - C The substance has a fixed composition of its constituents.
 - D The substance can be broken down into simpler forms by chemical means.
- 10 The following particles has different number of nucleons and electrons.

| Particle | Nucleon number | Number of electrons |
|---------------------|----------------|---------------------|
| Atom L | 26 | 12 |
| Ion M ²⁺ | 24 | 10 |

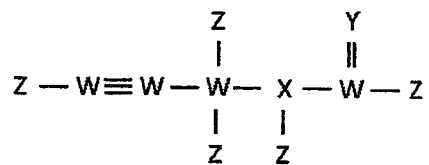
Which of the following statements about the particles is true?

- A Atoms L and M have different number of protons.
 - B Atoms L and M have different number of electrons.
 - C Atoms L and M have the same number of neutrons.
 - D Atoms L and M have similar chemical properties, but different physical properties.
- 11 An imaginary element has two isotopes:
- The first has 15 protons and a relative abundance of 80%
 - The second isotope has 16 neutrons.

If the relative atomic mass of the imaginary element is 30.2, determine the number of neutrons in the first isotope.

- A 15
- B 16
- C 30
- D 31

12 Study the molecule below:

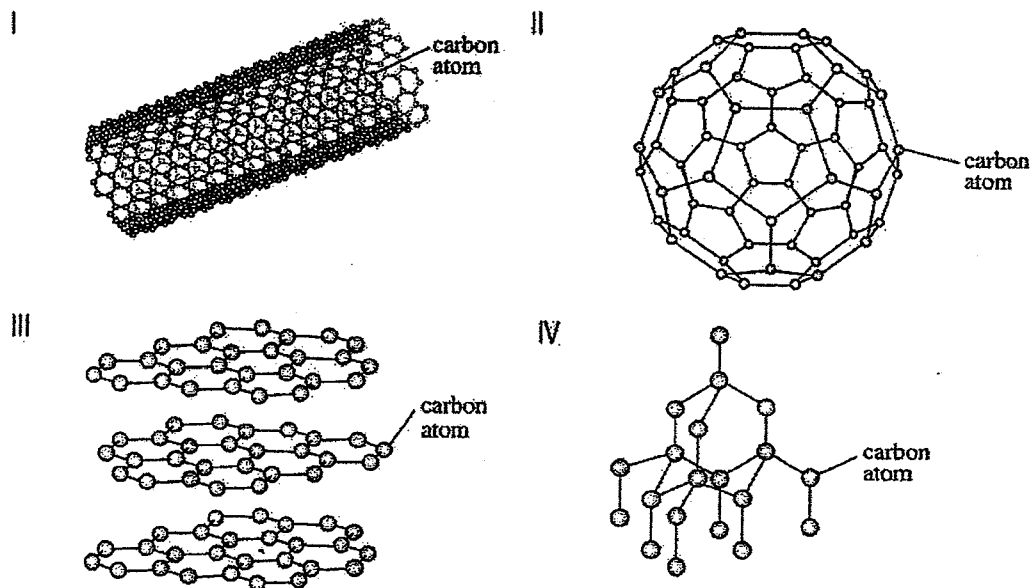


Suggest which Group of elements W, X, Y and Z could be from.

| | W | X | Y | Z |
|---|-----------|-----------|----------|-----------|
| A | Group III | Group V | Group VI | Group I |
| B | Group IV | Group III | Group VI | Group VII |
| C | Group III | Group V | Group II | Group I |
| D | Group IV | Group V | Group VI | Group VII |

13 Answer questions 13 and 14 using the diagram below.

Carbon can form different structures as shown:



Which structure(s) is/are likely to be electrical conductors?

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

14 Using the diagram on question 13, identify which structure(s) has/have a simple covalent structure.

- A II only
- B I and II only
- C I, II and III only
- D None of the above

15 The table below gives some information on four substances

| Substance | Melting point /°C | Boiling point /°C | Electrical conductivity | | Solubility in water |
|-----------|----------------------|----------------------|-------------------------|-----------|------------------------|
| | | | As solid | As liquid | |
| W | 17 | 118 | Poor | Poor | Soluble |
| X | 455 | 1547 | Poor | Good | Insoluble |
| Y | 1064 | 2970 | Good | Good | Insoluble |
| Z | 3550 | 4830 | Poor | Poor | Insoluble |

Which of the following statements is likely to be true?

- A W has a simple covalent structure.
 - B X has a giant metallic structure.
 - C Y is a polymer.
 - D Z is held together by electrostatic forces between oppositely charged ions.
- 16 Which of the following substances contains the largest number of atoms at room temperature and pressure?
- A 72 dm³ of argon
 - B 2 moles of bromine
 - C 24 g of carbon
 - D 3×10^{23} carbon dioxide
- 17 The percentage composition of hydrogen in a hydrocarbon is 11.1%. If 1 mole of the hydrocarbon combusts completely to form 3 moles of water, what could be the relative mass of the compound?
- A 14
 - B 27
 - C 54
 - D 56

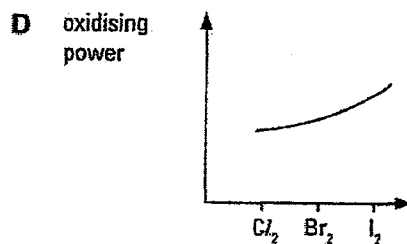
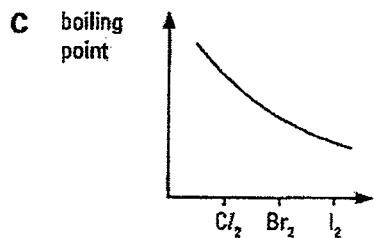
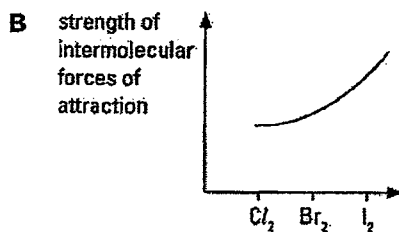
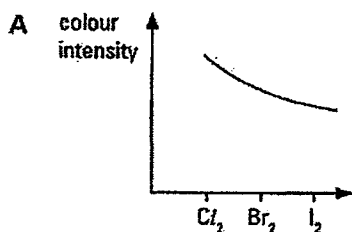
18 3.0 g of impure magnesium is added to 150 cm³ of 2.0 mol/dm³ dilute hydrochloric acid. What is the percentage purity of magnesium if only 2.4 dm³ of hydrogen gas was produced at the end of the reaction.

- A 40.0%
- B 62.5%
- C 80.0%
- D 83.3%

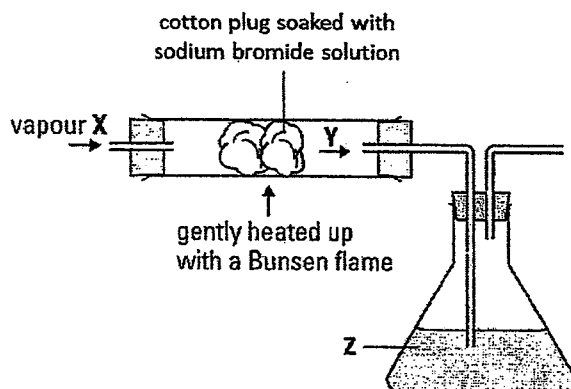
19 Which of the following statements about Group I metals is incorrect?

- A Reactivity increases down the group.
- B Melting point decreases down the group.
- C All Group I metals can react with cold water and the resultant solution turns red litmus paper blue.
- D When Group I metals are exposed to air, they react to form a grey metal oxide that is insoluble in water.

20 Which graph correctly describes a trend down Group VII?



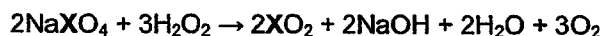
- 21 Vapour X was passed through a tube containing a cotton plug saturated with aqueous sodium bromide. The tube was warmed gently. The gas Y leaving the tube was then bubbled into Z.



What are the possible identities of substance X and Z, with the correct corresponding observations?

| | X | Z | Observation |
|---|----------|----------------------------|--|
| A | Fluorine | Liquid hexene | Brown vapour Y decolourised when in contact with Z |
| B | Chlorine | Aqueous potassium iodide | No colour change at Z |
| C | Iodine | Liquid octene | Brown vapour decolourised when in contact with Z |
| D | Iodine | Aqueous potassium chloride | Z turned greenish-yellow |

- 22 A substance NaXO_4 undergo a chemical reaction with hydrogen peroxide, according to the following equation:



What is the role of hydrogen peroxide in the above reaction?

- A It acts as a catalyst.
 B It is a reducing agent.
 C It is an oxidizing agent.
 D It is a dehydrating agent.
- 23 When acidified aqueous potassium iodide is added to iron(III) sulfate solution, what will be observed?
- A No visible change.
 B Pale yellow solution turns brown.
 C Pale green solution turns brown.
 D Pale yellow solution turns pale green.

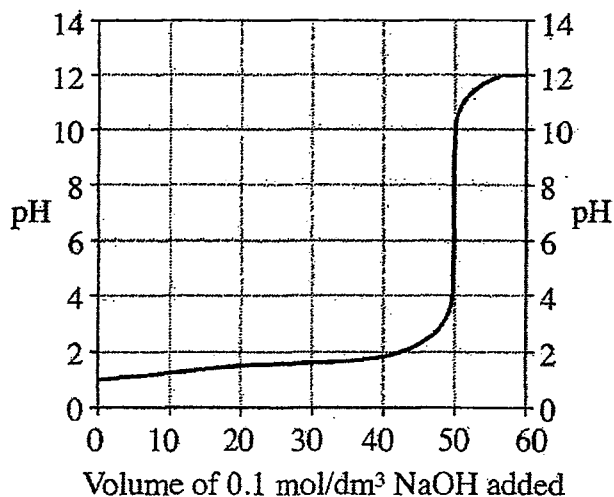
24 Which of the following statements about strong and weak acids is true?

- A There are no mobile OH^- ions present in all types of aqueous acids.
- B A weak dibasic acid will always have a faster rate of reaction as compared to a strong monobasic acid of the same concentration.
- C For the same basicity and concentration, weak acids have a lower pH than strong acids.
- D Regardless of strength, monobasic acids of the same concentration and volume require the same number of moles of aqueous sodium hydroxide for complete neutralization.

25 The chart below shows the colours of three indicators at different pH values:

| Indicator | Colour change Low pH \rightarrow high pH | pH which colour change takes place |
|------------------|---|---------------------------------------|
| Methyl orange | Red \rightarrow yellow | 4.0 |
| Bromothymol blue | Yellow \rightarrow blue | 6.5 |
| Phenolphthalein | Colourless \rightarrow pink | 9.0 |

Titration is carried out between aqueous sodium hydroxide and dilute hydrochloric acid. The pH change is plotted onto the graph shown below.



Which indicator(s) can be used to identify the end point of this titration?

- A Methyl orange only
- B Bromothymol blue only
- C Bromothymol blue and phenolphthalein only
- D Methyl orange, bromothymol blue and phenolphthalein

26 Which of the following salts can be prepared using the same method?

- A Zinc chloride, calcium sulfate
- B Potassium iodide, lead(II) iodide
- C Copper(II) sulfate, lead(II) nitrate
- D Ammonium chloride, magnesium nitrate

27 When aqueous lead(II) nitrate was added into an unknown solution, a white precipitate was formed. Subsequently, dilute nitric acid was added dropwise to the resultant mixture, till in excess. Effervescence was observed and the white precipitate dissolved completely.

Based on the observations, suggest what could be present in the unknown solution.

- A Zinc chloride
- B Ammonium iodide
- C Aluminium sulfate
- D Sodium carbonate

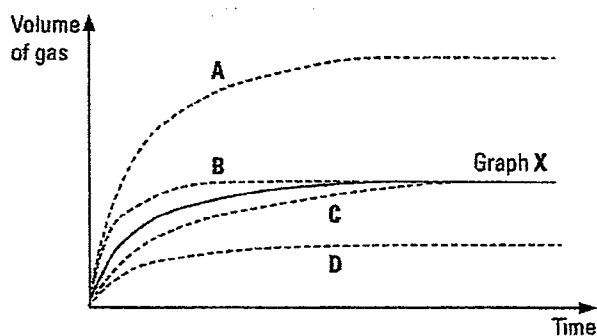
28 In experiment 1, one mole of ethane undergoes complete combustion to form carbon dioxide and water only. In experiment 2, one mole of butane is combusted completely instead. How will the activation energy and enthalpy change of experiment 2 be different from experiment 1?

| | Activation energy | Enthalpy change |
|---|-------------------|-----------------|
| A | Unchanged | Unchanged |
| B | Increase | Unchanged |
| C | Unchanged | Increase |
| D | Increase | Increase |

29 0.0100 mol of zinc powder is added to 100 cm³ of 0.100 mol/dm³ dilute hydrochloric acid at 25°C. The volume of gas produced is plotted against time as shown by Graph X below.

The experiment is then repeated using 0.0100 mol of **granulated** zinc with 100 cm³ of 0.200 mol/dm³ dilute hydrochloric acid at 50°C.

Which of the following graphs could be obtained for the second experiment?



30 Which gases can be removed by factories using moist calcium carbonate?

- A NO, NO₂, SO₂
- B HCl, NO, CH₄
- C CO, NO₂, CH₄
- D HCl, NO₂, SO₂

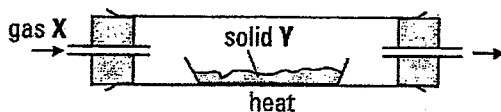
31 The table below provides information on the chemical properties of four metals and some of their compounds.

| Metal | Metal + Steam | Metal oxide + Coke | Metal carbonate heated strongly |
|-------|----------------------------|--------------------|---------------------------------|
| W | H ₂ gas evolved | Oxide reduced | CO ₂ evolved |
| X | H ₂ gas evolved | No visible change | No visible change |
| Y | No visible change | Oxide reduced | CO ₂ evolved |
| Z | H ₂ gas evolved | No visible change | CO ₂ evolved |

Which of the following shows the correct order of reactivity of the metals?

| | Most reactive | | → | least reactive | |
|---|---------------|---|---|----------------|---|
| A | Y | W | | Z | X |
| B | X | Z | | W | Y |
| C | Z | X | | W | Y |
| D | W | X | | Y | Z |

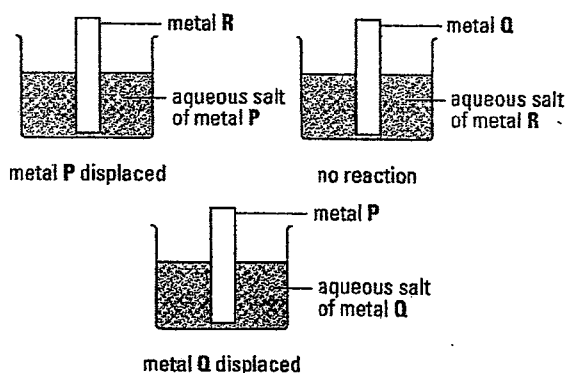
32 An unknown gas X is passed over heated solid Y, as shown below.



Which of the following pairs of reactants will undergo a reaction?

| | Gas X | Solid Y |
|---|-----------------|-----------------|
| A | Carbon monoxide | magnesium oxide |
| B | Carbon dioxide | Zinc oxide |
| C | Hydrogen | Iron(III) oxide |
| D | Steam | Lead |

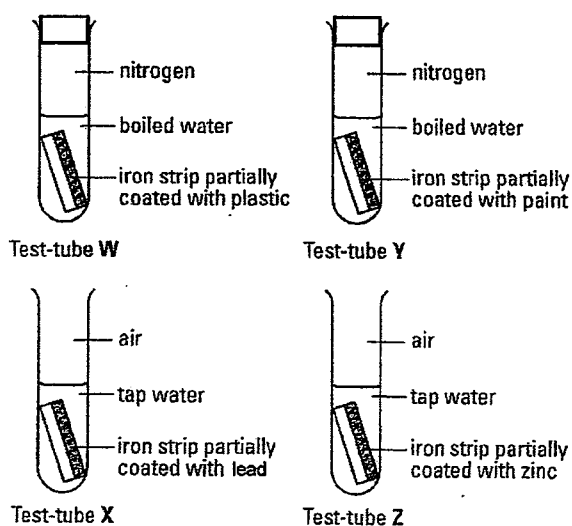
33 Three metals were added into three aqueous salts as shown.



Which one of the following gives the correct order of metal reactivity?

| | Least reactive | → | Most reactive |
|---|----------------|---|---------------|
| A | P | | Q R |
| B | P | | R Q |
| C | Q | | P R |
| D | Q | | R P |

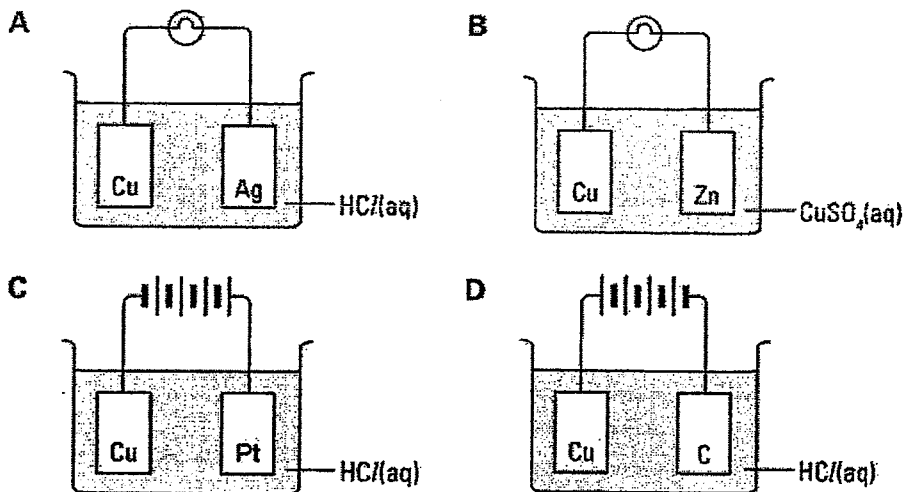
34 Four iron nails are placed in separate test tubes and subjected to different conditions as shown below.



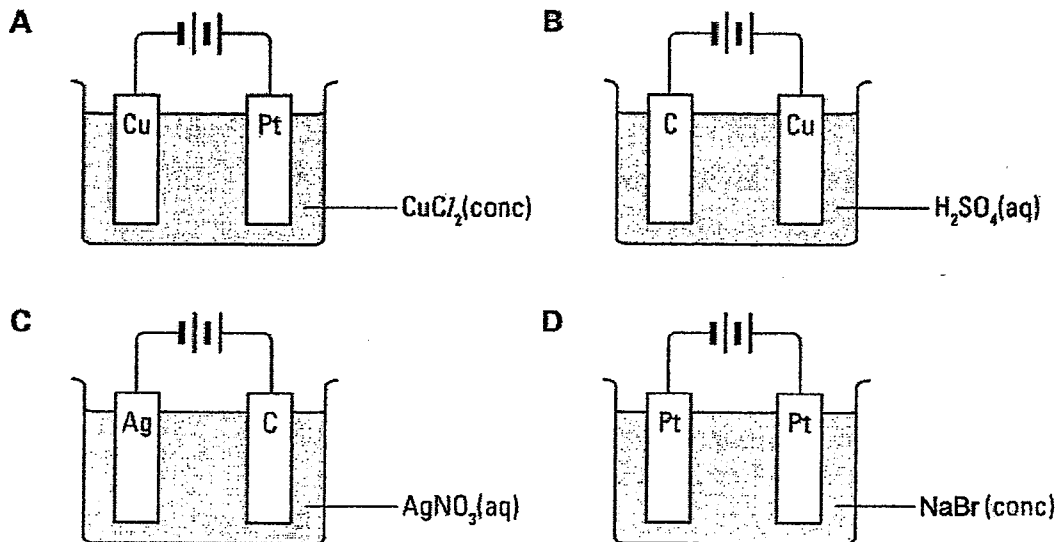
After some time, which of the above iron nails will rust?

- A X only
- B Z only
- C X and Z only
- D W and X only

- 35 Four experimental set ups are shown below. Which set up will produce bubbles of colourless, odourless gas around the copper electrode?



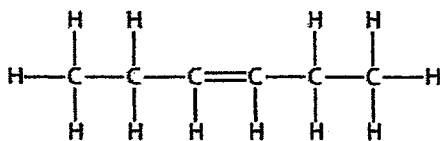
- 36 Four electrolytic cells are shown below. After a short period of time, which set up will the pH of electrolyte decreases the most significantly?



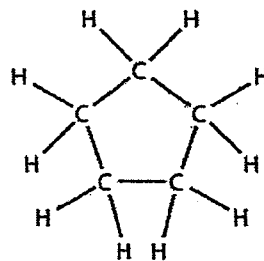
- 37 Which of the following statements describing naphtha and lubricating oil is true?

- A Naphtha is more flammable than lubricating oil.
- B Both naphtha and lubricating oil have sharp boiling points.
- C Naphtha consists of larger hydrocarbons than lubricating oil.
- D Naphtha is obtained below lubricating oil in a fractionating column.

38 The structures of molecules X and Y are shown below.



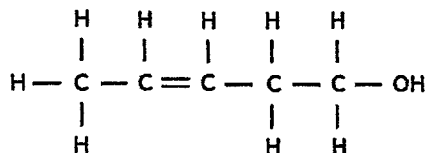
Molecule X



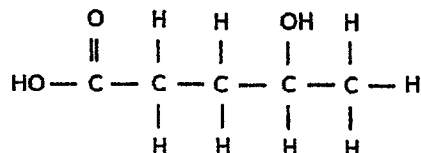
Molecule Y

Which of the following statements about the two molecules is true?

- A They are isomers of each other.
 B They have different empirical formula.
 C They have the same percentage composition.
 D They are from the same homologous series since their general formula is the same.
- 39 The labels on the containers of substances X and Y have been mixed up.



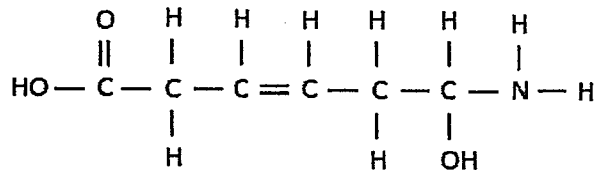
Substance X



Substance Y

Which chemical test can be used to distinguish between substances X and Y?

- A Adding copper metal
 B Aqueous sodium carbonate
 C Bromine under ultraviolet light
 D Warm acidified potassium manganate(VII) solution
- 40 The diagram below shows an organic molecule.



How many different types of polymer can be formed using the monomer above?

- A None
 B One
 C Two
 D Three

Answers to Section A: Circle the most appropriate answer to each question.

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

Name: _____ ()

Class: _____

SECONDARY 4 O LEVEL
PRELIMINARY EXAMINATION 2016

CHEMISTRY 5073

Paper 2

22 August 2016

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, register number, and class on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams or graphs.

Do not use highlighters, glue, correction fluid or correction tape.

Answer all questions.

Write all answers in the answer space provided.

If working is needed for any question it must be shown with the answer.

Give non-exact numerical answers correct to 3 significant figures unless a different level of accuracy is specified in the question.

The use of a scientific calculator is expected, where appropriate.

You are reminded of the need for clear presentation in your answers.

A copy of Periodic Table is provided on page 2.

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 is 80.

| For Examiner's Use | |
|--------------------|--|
| Section A (50) | |
| Section B (30) | |
| Total (80) | |

The Periodic Table of the Elements

| Group | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------------------------|-----------------------------|-----------------------------|-----------------------------|--------------------------------|------------------------------|------------------------------|-----------------------------|----------------------------|------------------------------|---------------------------|------------------------------|---------------------------|-----------------------------|----------------------------|-----------------------------|----------------------------|---------------------------|----------------------------|---------------------------|---------------------------|--------------------------|---------------------------|----------------------------|------------------------|---------------------------|----------------------------|------------------------|---------------------------|----------------------------|----------------------------|-------------------------|
| I | II | | III | | | | | | | | | | IV | V | VI | VII | 0 | | | | | | | | | | | | | | |
| 7 Li lithium 3 | 9 Be beryllium 4 | | | | | | | | | | | | | | | | | 4 He helium 2 | | | | | | | | | | | | | |
| 11 Na sodium 11 | 12 Mg magnesium 12 | | | | | | | | | | | | | | | | | 19 F fluorine 9 | 20 Ne neon 10 | | | | | | | | | | | | |
| 19 K potassium 19 | 20 Ca calcium 20 | 21 Sc scandium 21 | 22 Ti titanium 22 | 23 V vanadium 23 | 24 Cr chromium 24 | 25 Mn manganese 25 | 26 Fe iron 26 | 27 Co cobalt 27 | 28 Ni nickel 28 | 29 Cu copper 29 | 30 Zn zinc 30 | 31 Ga gallium 31 | 32 Ge germanium 32 | 33 As arsenic 33 | 34 Se selenium 34 | 35 Br bromine 35 | 36 Kr krypton 36 | | | | | | | | | | | | | | |
| 37 Rb rubidium 37 | 38 Sr strontium 38 | 39 Y yttrium 39 | 40 Zr zirconium 40 | 41 Nb niobium 41 | 42 Mo molybdenum 42 | 43 Tc technetium 43 | 44 Ru ruthenium 44 | 45 Rh rhodium 45 | 46 Pd palladium 46 | 47 Ag silver 47 | 48 Cd cadmium 48 | 49 In indium 49 | 50 Sn tin 50 | 51 Sb antimony 51 | 52 Te tellurium 52 | 53 I iodine 53 | 54 Xe xenon 54 | | | | | | | | | | | | | | |
| 55 Cs cesium 55 | 56 Ba barium 56 | 57 La lanthanum 57 | 58 Ce cerium 58 | 59 Pr praseodymium 59 | 60 Nd neodymium 60 | 61 Pm promethium 61 | 62 Sm samarium 62 | 63 Eu europium 63 | 64 Gd gadolinium 64 | 65 Tb terbium 65 | 66 Dy dysprosium 66 | 67 Ho holmium 67 | 68 Er erbium 68 | 69 Tm thulium 69 | 70 Yb ytterbium 70 | 71 Lu lutetium 71 | 72 Hf hafnium 72 | 73 Ta tantalum 73 | 74 W tungsten 74 | 75 Re rhenium 75 | 76 Os osmium 76 | 77 Ir iridium 77 | 78 Pt platinum 78 | 79 Au gold 79 | 80 Hg mercury 80 | 81 Tl thallium 81 | 82 Pb lead 82 | 83 Bi bismuth 83 | 84 Po polonium 84 | 85 At astatine 85 | 86 Rn radon 86 |
| 87 Fr francium 87 | 88 Ra radium 88 | 89 Ac actinium 89 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

*58-71 Lanthanoid series
†90-103 Actinoid series

| | | | | | | | | | | | | |
|---------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------|-------------------------------|-----------------------------|-------------------------------|-------------------------------|-----------------------------|---------------------------------|------------------------------|--------------------------------|
| 140 Ce cerium 58 | 141 Pr praseodymium 59 | 144 Nd neodymium 60 | 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 |
| 90 Th thorium 90 | 91 Pa protactinium 91 | 92 U uranium 92 | 94 Pu plutonium 94 | 95 Am americium 95 | 96 Cm curium 96 | 97 Bk berkelium 97 | 98 Cf californium 98 | 99 Es einsteinium 99 | 100 Fm fermium 100 | 101 Md mendelevium 101 | 102 No nobelium 102 | 103 Lr lawrencium 103 |

Key

| | |
|---|---|
| a | X |
| b | |

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

Section A

Answer all the questions in this section in the spaces provided.

The total mark for this section is 50.

A1 The following substances have different physical properties as shown below:

| Substance | Melting point/ °C | Boiling point/ °C | Solubility in water |
|-----------|-------------------|-------------------|---------------------|
| W | -114 | 78 | soluble |
| X | -6 | 300 | insoluble |
| Y | 801 | 1413 | soluble |
| Z | Sublimes at 338°C | | soluble |

When these substances are mixed, physical methods of separating them may include:

filtration sublimation simple distillation fractional distillation
 chromatography separating funnel crystallisation evaporation to dryness

- (a) Select from the above list, the best method(s) by which each of the following mixtures at room temperature may be separated, assuming that the components do not dissolve in each other.

You may use a method once, more than once or not at all.

(i) A mixture of **W** and **X**: _____ [1]

(ii) A mixture of **X** and **Y**: _____ [1]

(iii) A mixture of **Y** and **Z**: _____ [1]

(iv) A mixture of **W**, **X** and **water**: _____ [2]

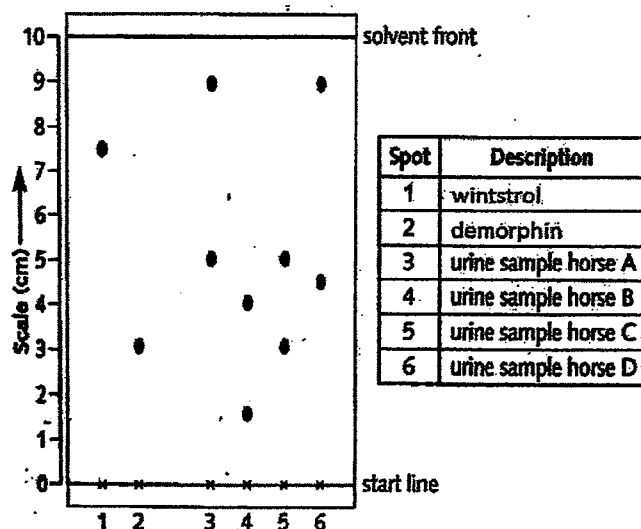
1. _____

2. _____

- (b) Chromatography is used by 'Horse Racing Forensic Laboratory' to test for the presence of illegal drugs in racehorses.

Concentrated samples of urine from racehorses are spotted onto chromatography paper on the start line. Alongside this, two known illegal drugs such as winstrol and demorphin are spotted. The chromatogram is run using methanol as the solvent. When finished, the chromatogram is analysed by placing under ultra-violet light.

A chromatogram of urine from four racehorses is shown below:



- (i) Calculate the R_f value of winstrol? [1]
-
- (ii) Will the R_f value of winstrol change if water, instead of methanol, was used as the solvent? Explain your answer. [1]
-
-
- (iii) State which horse was fed an illegal drug and name the drug used. [1]
-
- (iv) What is the purpose of ultra-violet light, when used to analyse the chromatogram? [1]
-

[9 Marks]

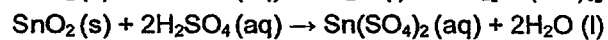
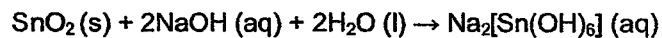
A2 Tin is a Group IV element. At room temperature, tin has a silvery white appearance and can conduct electricity. When cooled to low temperatures, the appearance of tin turns grey and the structure of tin transforms into one that resembles diamond.

- (a) In terms of bonding and structure, briefly explain why tin can conduct electricity at room temperature. [2]

- (b) State whether tin can conduct electricity at low temperatures. Explain your answer using bonding and structure. [2]

- (c) (i) Silicon is above tin in the Periodic Table. Silicon only has a structure similar to diamond and it reacts with oxygen to form silicon(IV) oxide, which is acidic in nature. [1]

Tin can also react with oxygen to form tin(IV) oxide. The tin(IV) oxide formed can undergo two reactions as shown below:



Suggest the nature of tin(IV) oxide.

- (ii) Hence, describe the trend of one chemical property for Group IV elements down the group. [1]

- (d) Describe the procedures required to obtain pure, dry silicon(IV) oxide from a mixture of silicon(IV) oxide and tin(IV) oxide. [3]

[9 Marks]

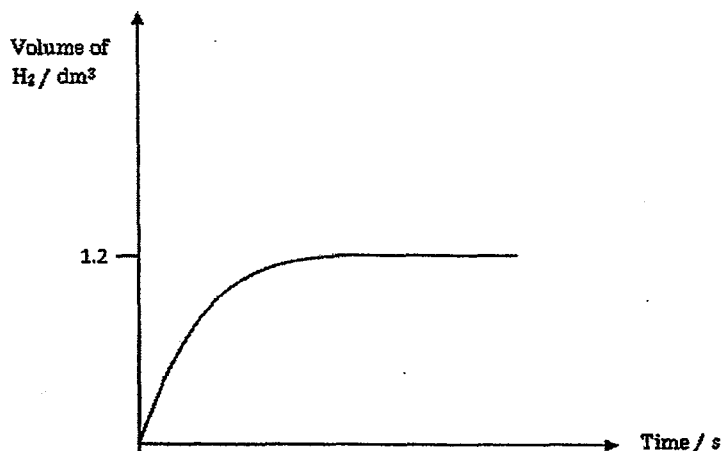
- A3 The strength of an acid can be indicated by its dissociation constant. The larger the dissociation constant value, the stronger the acid. The dissociation constant for some acids are given below.

| Type of Acid | Acid | Dissociation constant, K_a |
|--------------|--|------------------------------|
| Inorganic | Hydrochloric acid, HCl | 1.3×10^6 |
| | Nitric acid, HNO_3 | 2.5×10^1 |
| Organic | Methanoic acid, HCOOH | 1.8×10^{-4} |
| | Ethanoic acid, CH_3COOH | 1.75×10^{-5} |
| | Propanoic acid $\text{C}_2\text{H}_5\text{COOH}$ | 1.34×10^{-5} |
| | Oxalic acid, HOOC COOH | 5.9×10^{-2} |

- (a) (i) Using the table above, compare and comment on the general difference in the dissociation constants of organic and inorganic acids. Explain the difference in values with reference to the extent of dissociation. [2]

- (ii) Referring to the K_a values of methanoic acid, ethanoic acid and propanoic acid, describe the trend in strength within the carboxylic acid homologous series. [2]

- (b) Excess magnesium was added to 100 cm^3 of 1 mol/dm^3 aqueous methanoic acid. The time taken for the metal to produce hydrogen gas was measured and a graph was plotted as shown below.

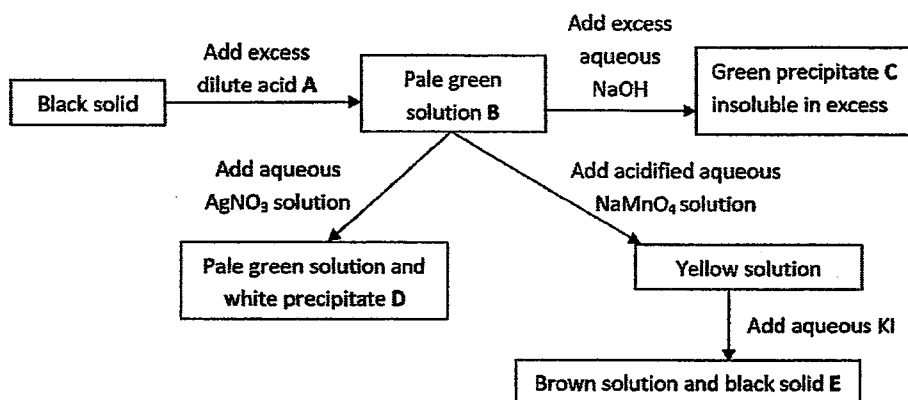


This experiment was then repeated using different dilute acids, but **keeping all the other conditions the same**.

- (i) On the same diagram, sketch a graph of the reaction when propanoic acid is used. Label this graph as **A**. [2]
- (ii) On the same diagram, sketch another graph of the reaction using nitric acid. Label this graph as **B**. [2]
- (iii) On the same diagram, sketch another graph of the reaction using oxalic acid. Label this graph as **C**. [2]
- (iv) Another student carried out the experiment with magnesium and oxalic acid dissolved in methylbenzene. Write down the observation. Explain your answer. [2]

[12 Marks]

A4 a The flow chart below shows a series of chemical tests involving substances A to E.



Give the chemical formula of substances A to E.

[5]

A:

B:

C:

D:

E:

b Write down the ionic equation for the formation of precipitate C.

[1]

[6 Marks]

A5 a When 3.10 g of copper(II) carbonate is added to 100 cm³ of 49.0 g/dm³ dilute sulfuric acid, calculate the maximum volume of carbon dioxide that can be produced, measured at room temperature and pressure. [2]

b If only 400 cm³ of carbon dioxide is obtained from the reaction in part a, what is the percentage yield of the reaction? [1]

c Using the collision theory, explain how an increase in temperature will affect the rate of reaction in part a. [2]

[5 Marks]

A6 a Pure titanium is extracted from its ore, rutile - TiO₂.
Rutile is first reacted with chlorine at 1000°C to produce titanium(IV) chloride and oxygen gas. The titanium(IV) chloride formed is then cooled and collected.

(i) Construct the chemical equation for the reaction above. [1]

(ii) Which is the oxidizing agent in the reaction above? Explain your answer using oxidation states. [2]

b Titanium(IV) chloride is then reacted with magnesium at 1100°C in a sealed reactor which is filled with argon gas. Titanium is then obtained at the end.

(i) Name the type of reaction that occurred in part b. [1]

(ii) Other than magnesium, suggest another metal which could be used in part b. [1]

(iii) Why is argon gas used to fill the sealed container instead of air? [2]

c Aluminium can also be added into titanium to form an alloy to increase the overall strength of the metals. [2]
In terms of structure, explain how the addition of aluminium strengthens titanium.

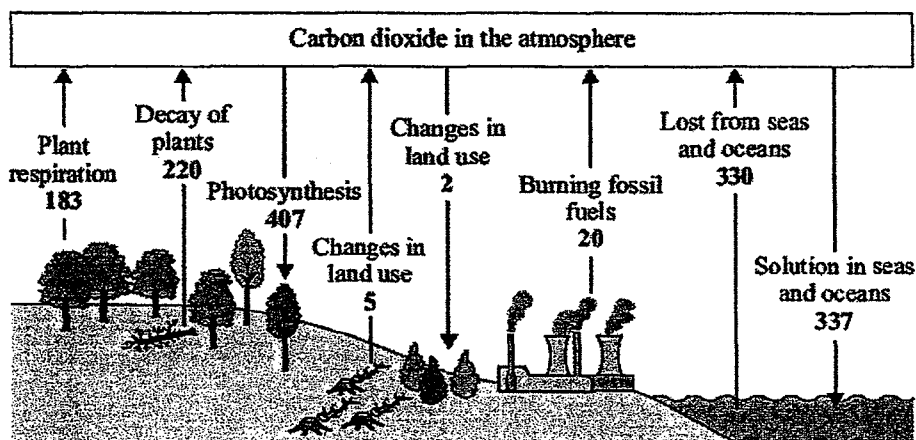
[9 Marks]

Section B

Answer all the 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.

- B7** Below shows a schematic diagram of the carbon cycle. The diagram contains environmental features such as plants, factories and oceans which contribute to the removal and release of carbon dioxide to the atmosphere. The amount of carbon dioxide removed or released are represented by numerical values on the diagram. The changes are measured in **billions of tonnes of carbon dioxide per year**.



- (a) (i) Sources of carbon dioxide contributors are not only limited to the features shown [1]
above. Suggest another source of carbon dioxide emission which is **not included** in the carbon cycle diagram.

- (ii) A carbon sink is an environmental feature that has a tendency to trap and store large amounts of carbon.

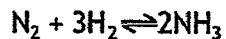
From the numerical data above, identify an environmental feature that is the most effective carbon sink on land. Explain your answer using values from the diagram. [2]

- (iii) Write a chemical equation to show how the environmental feature in part (a)(ii) trap and store carbon. [1]

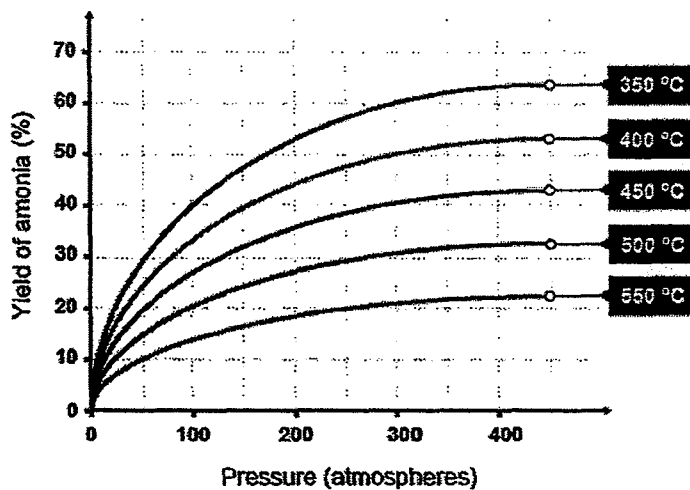
- (b)** Ocean acidification is one of the top environmental issues today. Ocean acidification refers to a decrease in the pH of the ocean over an extended period of time.
- (i)** Using numerical data from the carbon cycle diagram, explain how oceans are being acidified. [2]
-
-
-
- (ii)** The burning of fossil fuels such as coal also releases another gas that contributes to ocean acidification. Name this gas. [1]
-
- (iii)** What chemical can be used by factories to remove the gas in **(b)(ii)**? [1]
-
- (iv)** Write the chemical equation for the reaction in **(b)(iii)**. [1]
-
- (c)** Many marine organisms produce calcium carbonate structures and use them as a form of shelter. Suggest how ocean acidification will affect these organisms. [1]
-

[10 Marks]

B8 The Haber process produces ammonia from the reaction between nitrogen and hydrogen.



It is carried out at various temperatures and pressures to obtain different yields of ammonia as shown in the graph below.



- (a) From the graph, describe the relationship between temperature, pressure and the yield of ammonia. [2]

- (b) (i) Calculate the enthalpy change for the Haber process using the bond energies given below. [2]

| Type of bond | Bond energy (kJ/mol) |
|--------------|----------------------|
| H-H | 432 |
| N-H | 391 |
| N-N | 160 |
| N=N | 418 |
| NEN | 941 |

- (ii) From the answer in b(i), explain why the reaction is exothermic or endothermic in terms of bond breaking and bond formation. [2]

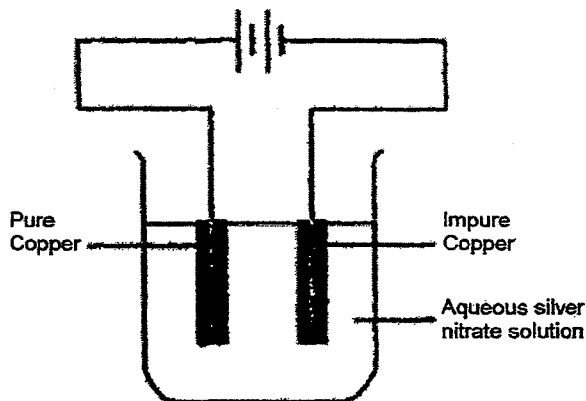
- (c) (i) State the conditions commonly used by industries to carry out the Haber process. [1]

- (ii) With the aid of a labelled energy profile diagram, explain how a catalyst affects the rate reaction in the Haber process. [3]

[10 Marks]

EITHER

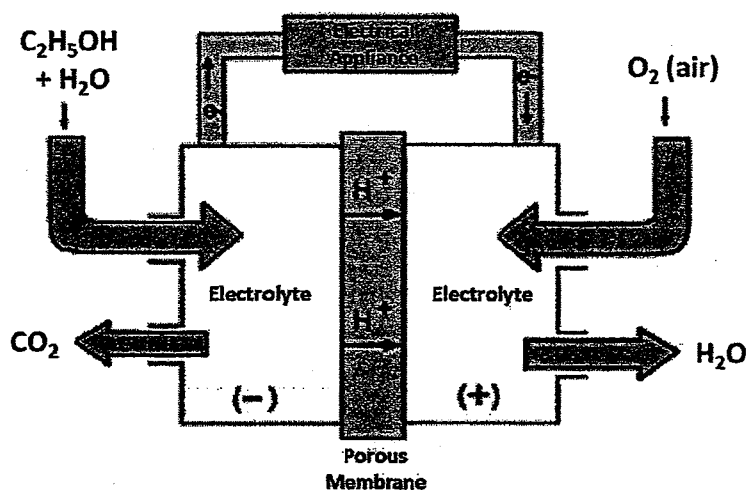
- B9** Copper extracted from the blast furnace can be further purified or refined using electrolysis. A student tried to carry out this process and set up an experiment as shown below.



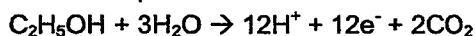
- (a) (i) The student failed to extract copper from the impure copper. State two changes that have to be made to the set up above for the purification process to be carried out properly. [2]

- (ii) If the anode in the **student's set-up** is changed to graphite, what will be observed at the anode and what happens to the pH of the electrolyte after some time? [2]

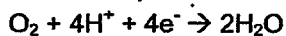
- (b) There are various forms of cells that can be used to generate electricity. Below shows the schematic diagram of a direct ethanol fuel cell (DEFC):



The half equation at the anode is:



The half equation at the cathode is:



- (i) Construct the overall equation for the reaction occurring in a DEFC. [2]

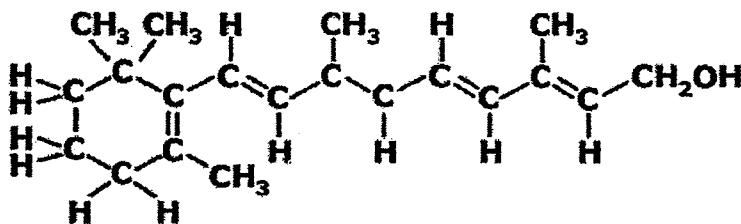
- (ii) If 4.00 moles of electrons flow through the electrical appliance, what is the maximum volume of carbon dioxide gas, at room temperature and pressure, that can be produced by the DEFC? [2]

- (c) Hydrogen can also be used in a fuel cell, state one advantage and one disadvantage of using hydrogen instead of ethanol in a fuel cell. [2]

[10 Marks]

OR

B9 Vitamin A, also known as retinol, is important for eye health and vision. Retinol has the following structure:

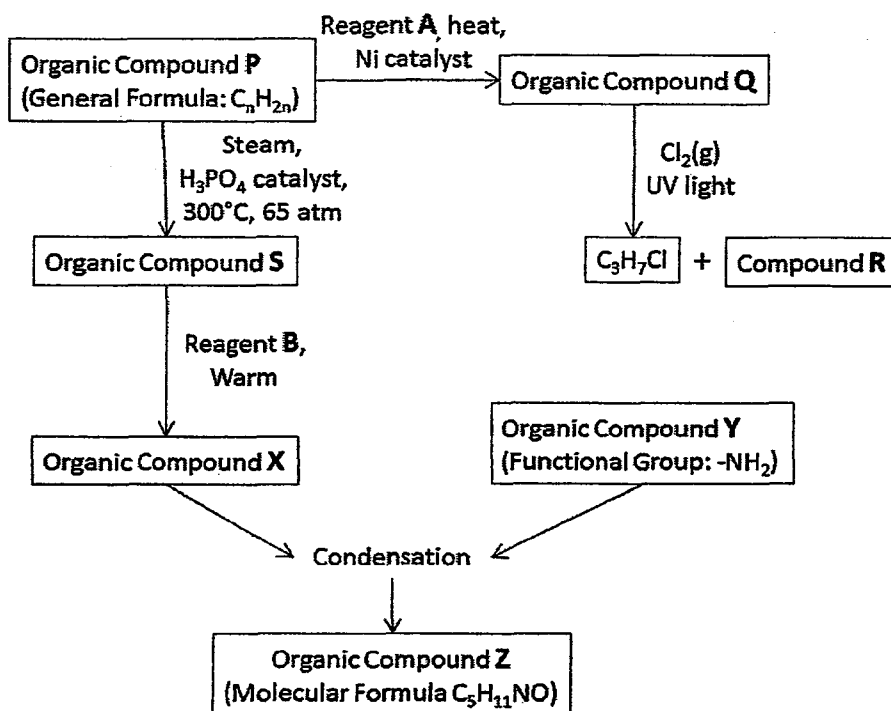


- (a) (i) How many moles of aqueous I₂ can react completely with 1 mol of Vitamin A in the dark? [1]

- (ii) Vitamin A (Retinol) is oxidized in the body to form retinoic acid, which helps to maintain skin health and bone growth.

Describe a chemical test that could be used to distinguish retinol from retinoic acid. State the corresponding observations. [2]

- (b) Organic compound P has the general formula C_nH_{2n} . It can undergo a series of [7] chemical reaction to form compound Z as shown in the chart below.



- (i) Identify and draw the full structural formulae of compounds P, Q, and R. [3]

P:

Q:

R:

- (ii) What is reagent A? [1]

- (iii) If compound S and compound X can react together to form a sweet smelling liquid, what is the name of reagent B? [1]

- (iv) What is the name of the sweet smelling liquid formed from compound S and compound X? [1]

- (v) Using information from the flow chart, write down the structural formula of compound Y. [1]

[10 Marks]

End of Paper 2

Mark scheme for Sec 4 Prelim 2016 Paper 2

Section A (50 marks)

| | | |
|----|------|---|
| A1 | ai | Separating funnel |
| | aii | Filtration |
| | aiii | Sublimation |
| | aiv | 1. Separating funnel, 2. Fractional distillation |
| | bi | 0.75 |
| | bii | Yes, X has <u>different solubility</u> in <u>different solvents</u> . |
| | biii | Horse C / Horse 5 Dermorphin / Demorphin |
| | biv | To make the spots <u>visible/seen</u> . OR <u>reveal/locate or identify</u> the position of the spots. |
| A2 | a | Tin has giant <u>metallic</u> structure/has <u>metallic</u> bonds. consists of cations in a <u>sea of delocalized electrons</u> The <u>electrons are mobile</u> |
| | b | Each <u>tin atom</u> uses all 4 of its <u>valence electrons</u> / <u>all valence electrons</u> used for <u>covalent bonds/bonding</u> <u>no mobile electrons</u> to conduct electricity |
| | ci | <u>Amphoteric</u> |
| | cii | Down group IV, the elements become <u>more metallic</u> in character. Down group IV, the elements turn from <u>non-metal to metal</u> . Down group IV, the elements <u>reducing property increases</u> . Down group IV, the oxides formed turn from <u>acidic to amphoteric</u> . Down group IV, the oxides formed become <u>more basic</u> . |
| | d | Add <u>excess</u> <u>Aq or dilute nitric acid/sulfuric acid/hydrochloric</u> <u>Filter</u> the mixture to <u>obtain the residue</u> <u>Wash</u> the residue with <u>distilled water</u> (if wash with wrong solution, do not award) <u>Dry</u> between sheets of <u>filter paper</u> |
| A3 | ai | <u>Inorganic</u> acids have <u>larger</u> dissociation constants than organic acids. OR Organic acids have K_a values that are less than 1 [0.5] Inorganic acids have K_a values that are more than 1 [0.5] <u>Inorganic/strong acids dissociates completely</u> |

| | | |
|----|-------------|--|
| | | <u>Organic/weak acids dissociates partially</u> |
| | aii | As the number of C atoms increases within the series or down the series the acids become <u>weaker</u> / strength decreases. Because K_a value <u>decreases</u> |
| | bi | Gentler initial slope, volume of H_2 at 1.2 dm^3 |
| | bii | Steeper initial slope, volume of H_2 at 1.2 dm^3 |
| | biii | Steeper initial slope than methanoic acid but gentler than initial slope of nitric acid, max volume of H_2 at 2.4 dm^3 |
| | biv | No visible change/no gas evolved/no effervescence (no reaction not accepted) Oxalic acid <u>does not ionize in methylbenzene</u> OR <u>only ionizes in water</u> to form mobile H^+ ions Hence it <u>does not display acidic properties / does not behave like an acid</u> |
| A4 | a | A: HCl B: $FeCl_2$ C: $Fe(OH)_2$ D: AgCl E: I_2 |
| | b | $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$ |
| A5 | a | No of mol of $CuCO_3 = 3.1 / 124 = 0.0250\text{ mol}$ No of mol of $H_2SO_4 = 49/98 \times 0.100 = 0.0500\text{ mol}$ $CuCO_3$ is the limiting reagent No of mol of carbon dioxide formed = 0.0250 mol Volume of carbon dioxide formed = 0.6 dm^3 |
| | b | % yield = $0.4/0.6 \times 100\% = 66.7\%$ |
| | c | Particles will have <u>more kinetic energy</u> . Proportion of particles with energy equal to or more than E_a increases. Greater frequency of collisions Greater frequency of effective collisions Faster rate of reaction |
| A6 | ai | $TiO_2 + 2Cl_2 \rightarrow TiCl_4 + O_2$ |
| | aii | Cl_2 is the oxidising agent. The oxidation state of <u>chlorine decreased</u> from <u>0 in Cl_2</u> <u>to -1 in $TiCl_4$</u> . Therefore, Cl_2 is <u>reduced</u> . |
| | bi | Displacement / Redox |
| | bii | Any metal above Mg in the reactivity series |
| | biii | Argon is a <u>noble gas/noble gas configuration</u> . It is <u>inert</u> (unreactive not accepted) |

| | | |
|--|----------|---|
| | | Prevents <u>Ti</u> from oxidizing back into <u>TiO₂</u> OR Prevents <u>Ti</u> from reacting with air or O ₂ OR Prevents the <u>more reactive metal</u> from reacting with air or O ₂ |
| | c | <u>Different sized atoms</u> <u>Disrupts the regular arrangement</u> <u>Layers unable to slide over each other</u> ("layers" must be included) |

Section B (30 marks)

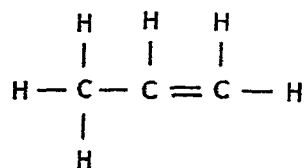
| | | |
|-----------|-------------|---|
| B7 | ai | Any 1 of the following: <u>Combustion of fuel in cars/aircrafts</u> <u>Animal Respiration</u> <u>Decay of dead animals</u> |
| | aii | Plants <u>take in 407</u> but <u>give out 183</u> and <u>220</u> billions of tonnes. OR <u>Overall</u> , plants absorb <u>4</u> (award 0m only if ans is 224) billions of tonnes. |
| | aiii | $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ If $6\text{CO}_2 + 12\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 12\text{H}_2\text{O}$, minus 1/2m (not balanced) |
| | bi | Oceans <u>take in 337</u> but only <u>give out 330</u> billions of tonnes. OR <u>Overall</u> , oceans absorb <u>7</u> billions of tonnes. Carbon dioxide is acidic / form carbonic acid |
| | bii | Sulfur dioxide |
| | biii | CaO, Ca(OH) ₂ , CaCO ₃ |
| | biv | $\text{CaCO}_3 + \text{SO}_2 \rightarrow \text{CaSO}_3 + \text{CO}_2$ OR $\text{CaO} + \text{SO}_2 \rightarrow \text{CaSO}_3$ OR $\text{CaCO}_3 + \text{H}_2\text{SO}_3 \rightarrow \text{CaSO}_3 + \text{CO}_2 + \text{H}_2\text{O}$ OR $\text{Ca(OH)}_2 + \text{SO}_2 \rightarrow \text{CaSO}_3 + \text{H}_2\text{O}$ |
| | c | Acids can <u>react with/corrode/remove/destroy</u> the carbonate structures |

| | | |
|------------------|-----|---|
| B8 | a | The <u>higher the temperature, the lower the yield</u> The <u>higher the pressure, the higher the yield</u> |
| | bi | 941 + 3(432) OR (+2237) -6(391) = OR (-2346) -109 kJ/mol |
| | bii | The <u>energy absorbed to break bonds</u> (used or required = 0m) Is <u>less than</u> the <u>energy released to form bonds</u> (used or required = 0m) Hence, energy is given out to the surroundings/ the reaction is exothermic OR hence ΔH is negative |
| | ci | Iron, 400°C, 200 atm |
| | cii | Correctly labelled axis Correctly drawn and labelled reactants and products Correctly drawn and labelled E_a (catalyzed) and E_a (uncatalysed) Correctly drawn curves (2 curves) Provides an alternative pathway With lower activation energy |
| B9 Eit her | ai | Switch the polarity of the battery OR swap the positions of the electrodes Change the electrolyte to aqueous copper(II) nitrate/chloride/sulfate |
| | aii | <u>Effervescence</u> is observed. pH of the electrolyte <u>decreases/ become more acidic</u> |
| | bi | $C_2H_5OH + 3H_2O \rightarrow 12H^+ + 12e^- + 2CO_2$ $3O_2 + 12H^+ + 12e^- \rightarrow 6H_2O$ $C_2H_5OH + 3H_2O + 3O_2 \rightarrow 2CO_2 + 6H_2O$ $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ |
| | bii | Max no of mol of CO_2 formed = $4 / 12 \times 2 = 0.6667$ mol Max vol of CO_2 formed = $0.6667 \times 24 = 16.0$ dm ³ |
| | c | The only product of the hydrogen fuel cell is <u>water</u> Ethanol fuel cell <u>produces CO_2</u> <u>Hydrogen gas needs to be liquefied</u> |
| B9 OR | ai | 4 mol |
| | aii | <u>Warm and acidified</u> <u>potassium manganate (VII) solution</u> will turn from <u>purple to colourless</u> when added to <u>retinol</u> <u>Effervescence</u> OR colourless gas <u>Water</u> when a reactive metal (must state the metal eg <u>Zn, Mg, etc</u>) |

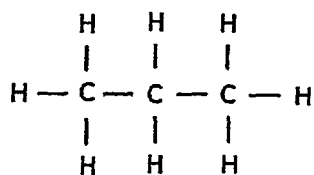
| | |
|--|---|
| | OR <u>aqueous sodium carbonate</u> is added to <u>retinoic acid</u> . |
|--|---|

bi

P:



Q:



R:



| | |
|------|--|
| bii | Hydrogen gas or H ₂ |
| biii | Acidified Aqueous potassium manganate(VII) |
| biv | Propyl propanoate |
| bv | CH ₃ CH ₂ NH ₂ OR C ₂ H ₅ NH ₂ |

