# Anglo-Chinese School (Barker Road)

## PRELIMINARY EXAMINATION 2017
## SECONDARY 4 EXPRESS

## CHEMISTRY
## 5073/01

## TIME: 1 HOUR

**INSTRUCTIONS TO CANDIDATES:**

Do not open this booklet until you are told to do so.

There are twenty multiple choice questions in this section. Select the best possible answer for each question, and indicate your response by shading the appropriate box in the optical answer sheet (OTAS) provided.

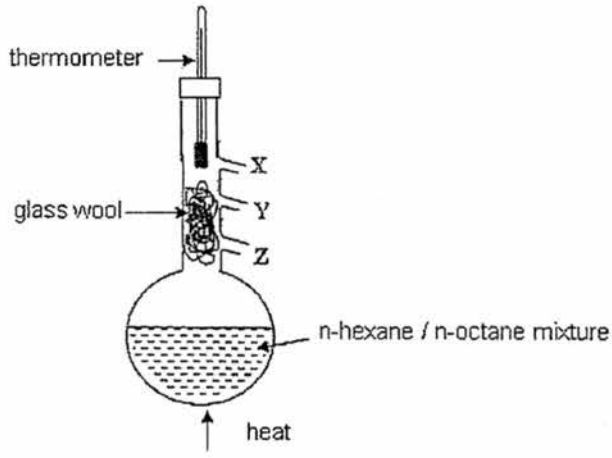
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Scientific calculators may be used.
A copy of the Periodic Table is printed on page 17.

*This question paper consists of **17** printed pages*

**Paper 1**
Answer all questions on the OTAS sheet provided.

**1.** A mixture of n-hexane (boiling point 69°C) and n-octane (boiling point 126°C) is heated in a fractional apparatus as shown in the diagram. Fractions are drawn off at the points labelled **X**, **Y** and **Z**.




Compared with the fractions drawn off at **Y** and **Z**, the fraction drawn off at **X** is likely to have

**A** the highest boiling point and the highest proportion of n-hexane.
**B** the highest boiling point and the lowest proportion of n-hexane.
**C** the lowest boiling point and the highest proportion of n-hexane.
**D** the lowest boiling point and the lowest proportion of n-hexane.

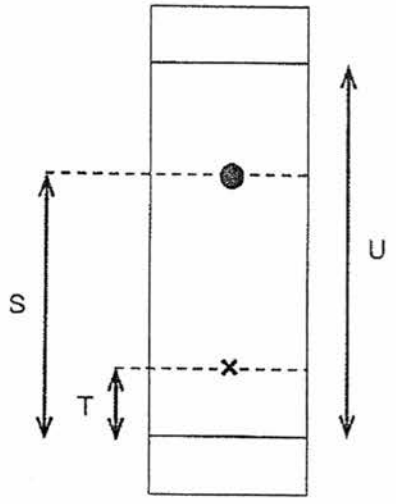
**2.** The properties of two substances are shown in the table below.

| substance | melting point (°C) | boiling point (°C) | solubility in water |
|---|---|---|---|
| **1** | –8 | 67 | insoluble |
| **2** | 95 | 210 | soluble |

Which is the best method to separate these two substances at room temperature and pressure?

**A** filtration
**B** paper chromatography
**C** separating funnel
**D** simple distillation

3. A substance is marked on a piece of filter paper at the point marked X, and placed in a solvent for some time. The resulting chromatogram is obtained.




What is the $R_f$ value of the dot obtained?

A $\frac{S}{U}$

B $\frac{T}{S}$

C $\frac{S-T}{U}$

D $\frac{S-T}{U-T}$

4. 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 gave two products
B the substance dissolves in water to give a colourless solution
C the substance has a fixed melting point
D when heated in air, the substance can form two types of oxides

5. Which statement about nitrogen atoms is **not** correct?

A All nitrogen atoms have the same atomic number.
B All nitrogen atoms have the same chemical properties.
C All nitrogen atoms have the same electronic configuration.
D All nitrogen atoms have the same mass number.

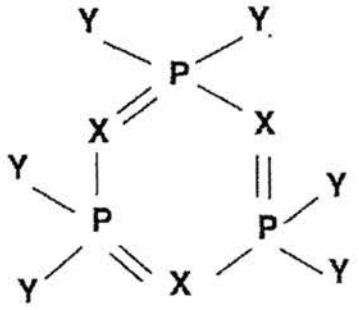
**6.** The table below shows the number of neutrons and electrons in the following four particles.

| particle | number of neutrons | number of electrons |
|---|---|---|
| **P** | 18 | 8 |
| $Q^+$ | 12 | 10 |
| $R^{2-}$ | 16 | 10 |
| **S** | 13 | 11 |

Which particle is an isotope of **P**?

**A** **Q**
**B** **R**
**C** **S**
**D** none of the above

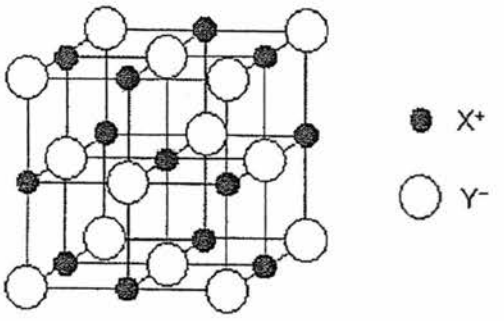
**7.** A molecule consists of three types of atoms, **P**, **X** and **Y**.




If **P** is phosphorus, what could **X** and **Y** be?

| | X | Y |
|---|---|---|
| **A** | Al | H |
| **B** | N | Cl |
| **C** | O | H |
| **D** | Si | Cl |

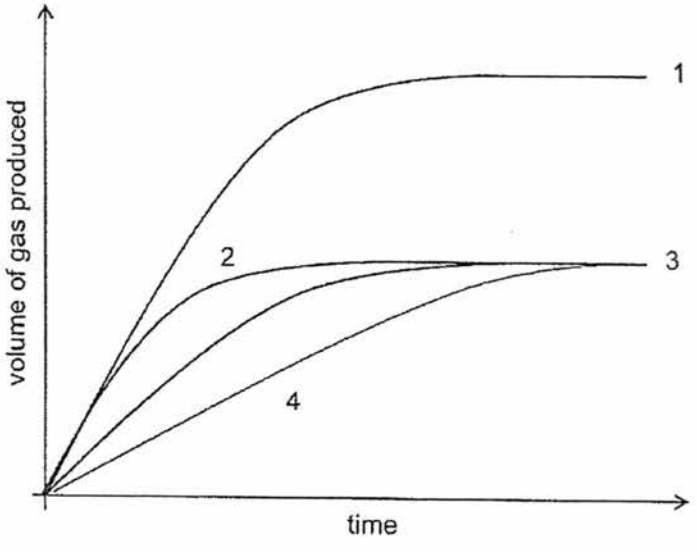
8. The diagram shows part of the structure of a salt, **XY**.




Which statement is correct?

**A** Each $Y^-$ ion is bonded to five $X^+$ ions.
**B** Each **X** atom is bonded to six **Y** atoms.
**C** The ratio of $X^+$ to $Y^-$ is 1 : 1.
**D** The structure shown is able to conduct electricity.

9. Sodium carbonate is added to 1.0 mol/dm$^3$ of excess ethanoic acid, hydrochloric acid and sulfuric acid separately.




Which correctly matches the graph to the acid used in each reaction?

| | sulfuric acid | hydrochloric acid | ethanoic acid |
|---|---|---|---|
| **A** | 1 | 2 | 4 |
| **B** | 1 | 4 | 3 |
| **C** | 2 | 3 | 4 |
| **D** | 2 | 4 | 3 |

**10.** Which pair of reactants is best used to prepare the corresponding salt?

| | reactant 1 | reactant 2 | salt |
|---|---|---|---|
| A | ammonium chloride | nitric acid | ammonium nitrate |
| B | barium carbonate | sulfuric acid | barium sulfate |
| C | copper | hydrochloric acid | copper(II) chloride |
| D | sodium hydroxide | sulfuric acid | sodium sulfate |

**11.** Which pair of reactants, when mixed, will react as shown in the ionic equation below?

$$Pb^{2+}\,(aq) + SO_4^{2-}\,(aq) \rightarrow PbSO_4\,(s)$$

**A** lead(II) chloride and sodium sulfate
**B** lead(II) nitrate and sulfuric acid
**C** lead(II) oxide and sulfuric acid
**D** lead(II) sulfate and water

**12.** Which substance contains the most number of molecules in 1 g?

**A** $O_2$
**B** CO
**C** $NO_2$
**D** $SO_2$

**13.** Tin is extracted from its ore cassiterite (which contains $SnO_2$) by reduction by carbon in a blast furnace according to the equation below.

$$SnO_2 + 2\,C \rightarrow Sn + 2\,CO$$

What is the percentage purity of tin ore if 600g of cassiterite on reduction produces 82g of tin? ($M_r$ of $SnO_2$ = 151, $M_r$ of Sn = 119)

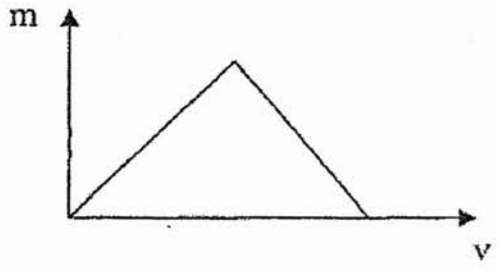
**A** $\frac{82}{119} \times \frac{600}{151} \times 100\%$
**B** $\frac{82}{119} \times \frac{151}{600} \times 100\%$
**C** $\frac{119}{82} \times \frac{600}{151} \times 100\%$
**D** $\frac{119}{82} \times \frac{151}{600} \times 100\%$

**14.** When an aqueous salt was warmed with aqueous sodium hydroxide and aluminium foil, a gas which turned moist red litmus paper blue was evolved.

Which of the following could **not** be the aqueous salt?

A ammonium chloride
B ammonium nitrate
C sodium chloride
D sodium nitrate

**15.** In a test for the presence of a cation in an aqueous salt solution, aqueous sodium hydroxide is added slowly until in excess. The diagram shows how the mass (m) of the precipitate varies with the volume (v) of sodium hydroxide added.




Which of the following could **not** be the aqueous salt?

A aluminium nitrate
B calcium nitrate
C lead(II) nitrate
D zinc nitrate

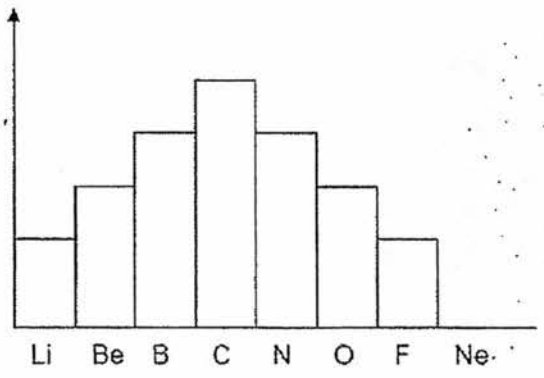
**16.** A series of tests are carried out on an unknown gas. The table below shows the tests and the results obtained.

| test | result |
|---|---|
| moist blue litmus paper | no change |
| aqueous bromine | no change |
| lighted splint | extinguishes |

What could the gas be?

A ammonia
B chlorine
C ethene
D oxygen

**17.** The bar chart shows the period of elements from lithium to neon.




Which is the correct label for the y-axis?

**A** the atomic number
**B** the number of electrons involved in bonding
**C** the number of valence electrons
**D** the relative atomic mass

**18.** Astatine can be found in Group VII of the Periodic Table.

Which statement is correct?

**A** Astatine can conduct electricity.
**B** Astatine forms a soluble silver salt.
**C** Astatine can form both ionic and covalent compounds.
**D** Astatine occupies 24 $dm^3$ at room temperature and pressure.

**19.** In which reaction is sulfur dioxide acting as an oxidizing agent?

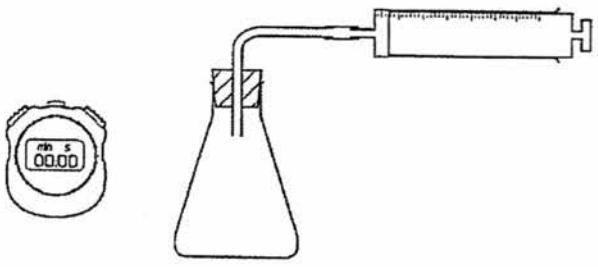
**A** $SO_2 + 2\ H_2O + Cl_2 \rightarrow H_2SO_4 + 2\ HCl$
**B** $SO_2 + 2\ NaOH \rightarrow Na_2SO_3 + 2\ H_2O$
**C** $2\ SO_2 + O_2 \rightarrow 2\ SO_3$
**D** $SO_2 + H_2S \rightarrow 2\ H_2O + 3\ S$

**20.** An unknown substance **Z** is added to aqueous potassium iodide, and there was no visible change observed.

Which statement describing **Z** is definitely true?

**A** Z is a reducing agent.
**B** Z is an oxidizing agent.
**C** Z is not a reducing agent.
**D** Z is not an oxidizing agent.

**21.** The apparatus shown below can be used to investigate the rate of a reaction.




In which reaction could the rate of reaction be followed using these apparatus?

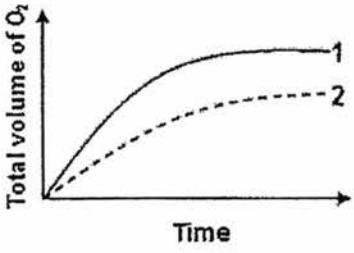
**A** $AgNO_3 + HCl$
**B** $Mg + HCl$
**C** $NaOH + HCl$
**D** $NH_4NO_3 + HCl$

**22.** Aqueous hydrogen peroxide decomposes to form water and oxygen gas. Two experiments were carried out to measure the rate of production of oxygen from aqueous hydrogen peroxide.

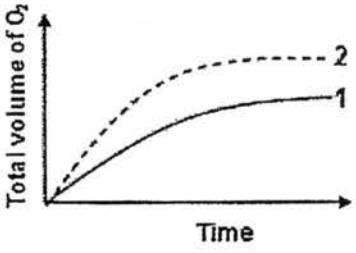
| experiment | reagent used |
|---|---|
| 1 | 400 $cm^3$ of 0.2 $mol/dm^3$ of hydrogen peroxide |
| 2 | 100 $cm^3$ of 1.0 $mol/dm^3$ of hydrogen peroxide |

Which graph best shows the results obtained?

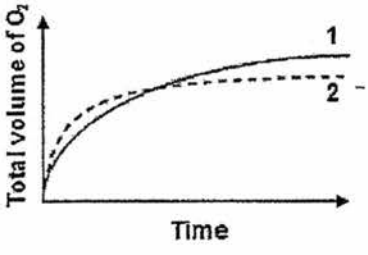
A



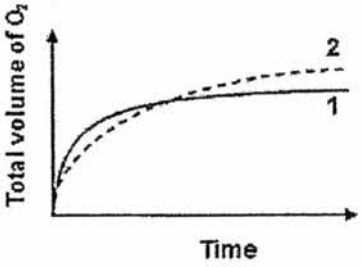

B




C




D



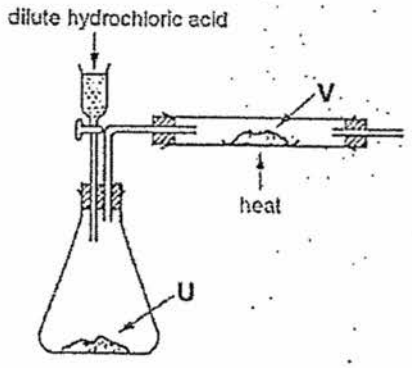

**23.** Which statement about the manufacture of ammonia via the Haber Process is **not** correct?

A A high pressure will increase the yield of ammonia.
B A high temperature will increase the yield of ammonia.
C An iron catalyst is used to speed up the rate of reaction.
D It is a redox reaction.

**24.** Which of the following is **not** correct about the type of steel and its use being described?

| | **type of steel** | **use** |
|---|---|---|
| A | low carbon steel | cutting tools |
| B | low carbon steel | used to make car bodies |
| C | stainless steel | cutlery |
| D | stainless steel | surgical instruments |

25. The diagram shows an experimental set up used to reduce substance **V**. Which of the following pairs could be **U** and **V**?




| | U | V |
|---|---|---|
| A | copper | copper(II) oxide |
| B | copper | lead(II) oxide |
| C | lead | lead(II) oxide |
| D | magnesium | copper(II) oxide |

26. Which statement about transition metals is **not** correct?

A Transition metals can behave as catalysts.
B Transition metals have high melting and boiling points.
C Transition metals can have variable oxidation states.
D Transition metals tend to be coloured.

27. Which correctly matches the air pollutant to its source and effect?

| | air pollutant | source | effect |
|---|---|---|---|
| A | carbon monoxide | combustion of fuels | global warming |
| B | nitrogen dioxide | car engines | acid rain |
| C | ozone | photochemical smog | depletes the ozone layer |
| D | sulfur dioxide | lightning activity | acid rain |

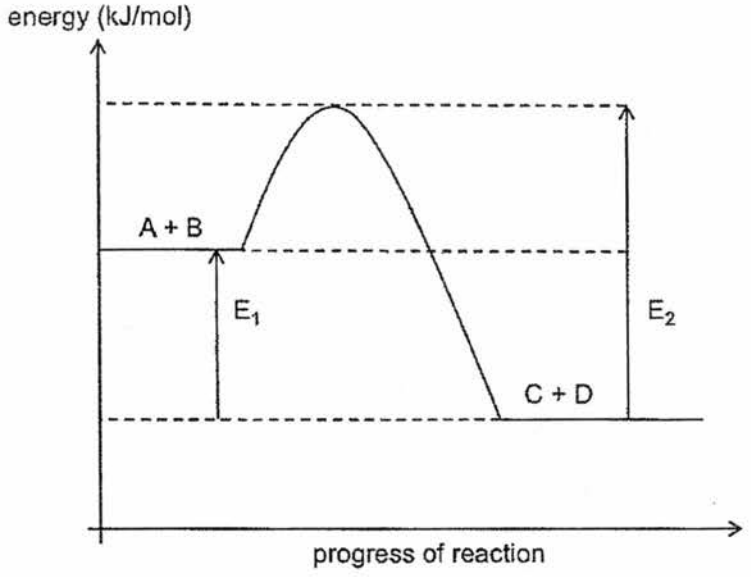
28. Which statement about hydrogen as a fuel is correct?

A Hydrogen can be obtained by fractional distillation of crude oil.
B Hydrogen is the main component found in natural gas.
C Hydrogen is a fuel that is easily transported and stored.
D Hydrogen reacts with oxygen to produce energy and water.

**29.** The equation below represents a reversible reaction.

$$A + B \rightleftharpoons C + D$$

The energy profile diagram of the reaction shown.




Which statement is correct?

**A** $E_1$ is the enthalpy change of the forward reaction.
**B** $E_2$ is the enthalpy change of the backward reaction.
**C** $(E_2 - E_1)$ is the activation energy of the backward reaction.
**D** $(E_2 - E_1)$ is the activation energy of the forward reaction.

**30.** Which pair of statements correctly describes the differences between the conduction of electricity by electrolytes and the conduction of electricity by metals during electrolysis?

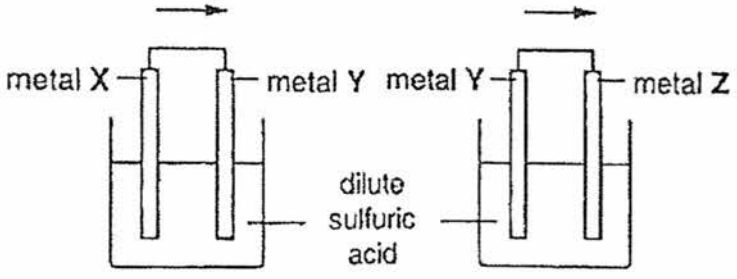
| | conduction by electrolytes | conduction by metals |
|---|---|---|
| 1 | the current is due to the movement of ions | the current is due to the movement of electrons |
| 2 | charged particles move towards both electrodes | charged particles move in one direction only |
| 3 | it always results in a chemical change | it never results in a chemical change |

**A** only 1 is correct
**B** only 1 and 2 are correct
**C** only 2 and 3 are correct
**D** 1, 2 and 3 are correct

**31.** In electroplating a chromium bracelet with silver, which combination of anode, cathode and electrolyte is most suitable?

| | anode | cathode | electrolyte |
|---|---|---|---|
| A | bracelet | silver | chromium(III) nitrate |
| B | bracelet | silver | silver nitrate |
| C | silver | bracelet | chromium(III) nitrate |
| D | silver | bracelet | silver nitrate |

**32.** Two cells were set up as shown below. The arrows show the direction of electron flow in the external circuit.




Which set of metals would cause electron flow in the directions shown?

| | metal X | metal Y | metal Z |
|---|---|---|---|
| A | Ag | Zn | Cu |
| B | Cu | Ag | Zn |
| C | Zn | Ag | Cu |
| D | Zn | Cu | Ag |

**33.** Which correctly matches the crude oil fraction to its use?

| | fraction | use |
|---|---|---|
| A | bitumen | chemical feedstock |
| B | diesel | paving road surfaces |
| C | naphtha | fuel for cooking |
| D | paraffin | aircraft fuel |

**34.** Two hydrocarbons have the same percentage by mass of carbon and hydrogen.

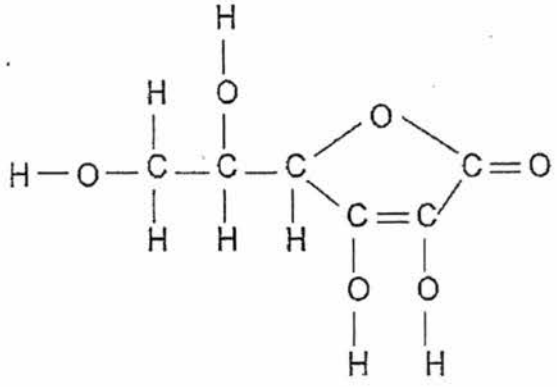
Which statement is true for both hydrocarbons?

**A** They belong to the same homologous series.
**B** They have similar chemical properties.
**C** They have the same empirical formula.
**D** They have the same molecular formula.

**35.** In which reaction is water **not** a product?

**A** combustion
**B** esterification
**C** fermentation
**D** neutralization

**36.** The structural formula of an organic compound is shown below.



Which substance(s) can react with this compound?

**I** acidified potassium manganate(VII)
**II** aqueous bromine
**III** sodium carbonate

**A** I and II only
**B** I and III only
**C** II and III only
**D** I, II and III

37. A student investigated the reaction of different vegetable oils with hydrogen.

100 $cm^3$ of hydrogen was passed through 1 g samples of vegetable oils containing a suitable catalyst. The volume of hydrogen gas remaining in each reaction was recorded in the table below.

| vegetable oil | volume of hydrogen remaining ($cm^3$) |
|---|---|
| P | 100 |
| Q | 87 |
| R | 0 |

Which vegetable oil(s) is/are unsaturated?

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

38. The reaction between a carboxylic acid, $C_xH_yCOOH$ and an alcohol, $C_zH_{2z+1}OH$ produces an ester.

How many carbon, hydrogen and oxygen atoms are there in this ester?

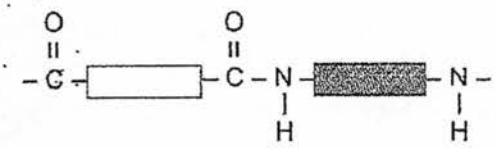
| | number of carbon atoms | number of hydrogen atoms | number of oxygen atoms |
|---|---|---|---|
| A | x + z | y + 2z | 2 |
| B | x + z | y + 2z + 1 | 2 |
| C | x + z + 1 | y + 2z | 2 |
| D | x + z + 1 | y + 2z + 1 | 2 |

39. In the polymerization of ethene to polyethene, there is **no** change in

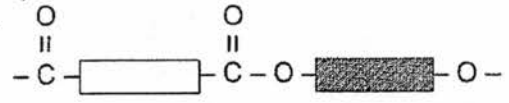
A boiling point.
B density.
C empirical formula.
D molecular formula.

**40.** What is the correct structure of nylon?

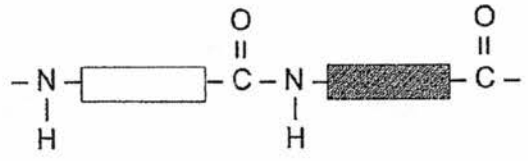
**A**



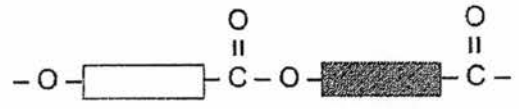
**B**



**C**



**D**



# The Periodic Table of the Elements

| Group I | Group II | | | | | | | | | | | Group III |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 H hydrogen 1 | | | | | |
| 7 Li lithium 3 | 9 Be beryllium 4 | | | | | | | | | | | 11 B boron 5 |
| 23 Na sodium 11 | 24 Mg magnesium 12 | | | | | | | | | | | 27 Al aluminium 13 |
| 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 |
| 85 Rb rubidium 37 | 88 Sr strontium 38 | 89 Y yttrium 39 | 91 Zr zirconium 40 | 93 Nb niobium 41 | 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 |
| 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 |
| – Fr francium 87 | – Ra radium 88 | – Ac actinium 89 † | | | | | | | | | | |

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

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.).

| Exam Index Number | |
|---|---|

# Anglo-Chinese School (Barker Road)

## PRELIMINARY EXAMINATION 2017
## SECONDARY 4 EXPRESS

## CHEMISTRY
## 5073/02

## TIME: 1 HOUR 45 MINUTES

**INSTRUCTIONS TO CANDIDATES:**
Write your Exam Index Number in the box provided at the top of this page.
Candidates are reminded that all quantitative answers should include appropriate units.
Candidates are advised to show all their working in a clear and orderly manner.

**Sections A**
Answer **all** questions in the spaces provided on the question paper.

**Sections 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.

**INFORMATION FOR CANDIDATES:**

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

| For Examiner's Use Only | |
|---|---|
| Section A | |
| B7 | |
| B8 | |
| B9 | |
| TOTAL | |

*This question paper consists of 23 printed pages*

**Section A**

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

**A1.** The letters **A**, **B**, **C**, **D**, **E**, **F** and **G** show the oxides of some elements.

| | |
|---|---|
| **A** | $K_2O$ |
| **B** | CaO |
| **C** | $Al_2O_3$ |
| **D** | CO |
| **E** | NO |
| **F** | PbO |
| **G** | $SiO_2$ |

Use the letters **A**, **B**, **C**, **D**, **E**, **F** and **G** to answer the questions below. The letters can be used once, more than once, or not at all.

**(a)** Which substance(s) is/are neutral oxides?

.....[1]

**(b)** Which substance can be used to control the pH of soil?

.....[1]

**(c)** Which substance(s) is/are involved in the Blast Furnace reactions?

.....[1]

**(d)** Which two substances can be used to convert naphtha into ethene?

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

**(e)** Give the chemical formula for the compound formed from the reaction between **F** and **G**.

.....[1]

**(f)** Describe a test you could carry out in the laboratory to distinguish aqueous solutions of compounds **A** and **B**.

.....

.....

.....[2]

[total = 7 marks]

**A2.** Chlorofluorocarbons (CFCs) were widely used in refrigerants and aerosol products before the 1990s, until they were phased out by several countries due to their negative impact on the environment.

**(a)** Describe the negative impact CFCs have on human beings and the environment.

.....

.....[1]

**(b)** Applications of CFCs make use of their volatility and low reactivity.

The table shows the properties of some common CFC refrigerants.

| name of CFC | formula of CFC | boiling point (°C) |
|---|---|---|
| Freon-11 | $CCl_3F$ | 23 |
| Freon-12 | $CCl_2F_2$ | –30 |
| Freon-31 | $CH_2ClF$ | –9 |

**(i)** "The boiling point of the CFC increases with the size of the molecule."

Do you agree with this statement? Use the information in the table to explain your reasoning.

.....

.....

.....[2]

**(ii)** Freon-13, is composed of 11.5% by mass of carbon, 34% by mass of chlorine, and the remainder being fluorine.

Deduce, by calculation, the molecular formula of Freon-13.

[3]

[total = 6 marks]

**A3.** A catalytic converter is an emissions control device that converts toxic gases and pollutants into less harmful gases.

**(a)** These days, most cars are installed with catalytic converters that removes carbon monoxide and nitrogen dioxide:

$$2\ NO_2 + 2\ CO \rightarrow N_2 + 2\ CO_2$$

**(i)** Explain, in terms of oxidation states, why this is a redox reaction.

.....

.....

.....[2]

**(ii)** A car company advertises that "catalytic converters are 100% environmentally friendly".

Do you agree with this statement? Explain your reasoning.

.....

.....[1]

**(b)** In a typical catalytic converter, a powdered catalyst such as platinum is used to speed up the conversion of gases.

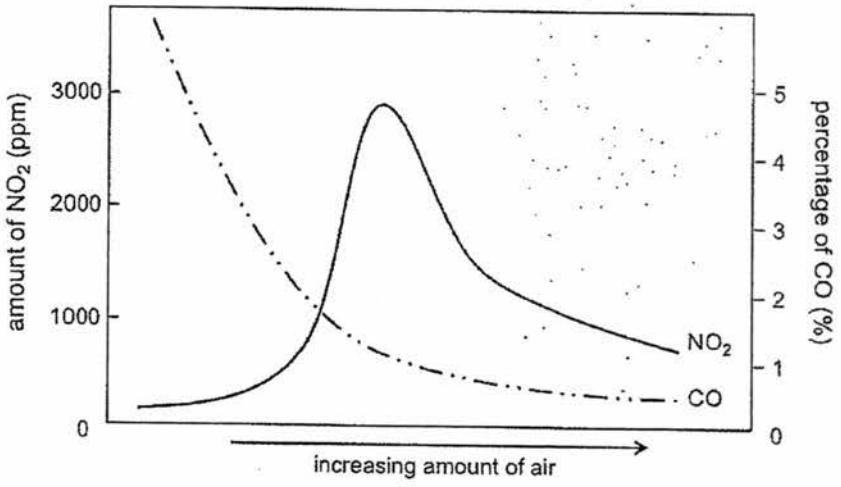
Explain, in terms of reacting particles, why the catalyst is powdered.

.....

.....

.....[2]

**(c)** The graph shows how the amount of nitrogen dioxide (measured in ppm) and carbon monoxide (measured in %) vary depending on how much air is present in the car engine.




**(i)** Describe how the amounts of nitrogen dioxide and carbon monoxide vary with the amount of air in the car engine.

.....

.....

.....

.....[2]

**(ii)** Making use of the redox reaction given in **(a)**, and considering how nitrogen dioxide and carbon monoxide are formed in the car engine, explain why the amounts of nitrogen dioxide and carbon monoxide vary in this way.

.....

.....

.....

.....

.....

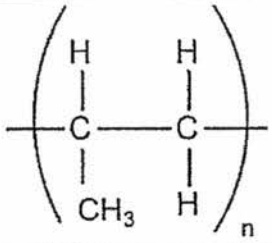
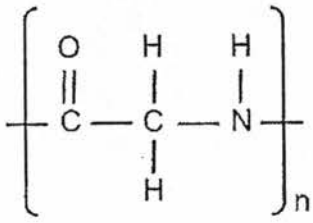
.....

.....[3]

[total = 10 marks]

**A4.** Polymers have several uses, and can be found almost everywhere.

Some information about two polymers are shown below.

| name of polymer | polypropene | polyglycine |
|---|---|---|
| structural formula |  |  |
| name of monomer | propene | glycine |
| average $M_r$ | 2000 – 4000 | 2000 – 5000 |

**(a)** Polyglycine is a polyamide, which is made by the condensation polymerization of the amino acid monomer, glycine.

**(i)** Draw the full structural formula of the monomer, glycine.

[1]

**(ii)** Describe one similarity and one difference between the **structures** of the addition polymer, polypropene, and the condensation polymer, polyglycine.

.....

.....

.....

.....

.....

.....[2]

**(iii)** The condensation polymerization of glycine to produce one molecule of polyglycine eliminates 990 g of water.

Calculate the relative molecular mass of this molecule of polyglycine, showing all your working ($M_r$ of glycine is 75).

[2]

**(b)** Propene is the monomer used to prepare polypropene, which is widely used to make plastics.

**(i)** In terms of bonding and structure, explain why propene is a gas but polypropene is a solid at room temperature.

.....

.....

.....

.....

.....[2]

**(ii)** Explain how aqueous bromine can be used to monitor the conversion of propene to polypropene.

.....

.....

.....

.....[2]

[total = 9 marks]

**A5.** Acid-base titration is often carried out in the laboratory, and the progress of the titration can be monitored using a data logger (pH meter).

The graph below shows the resulting pH curve when 1.0 mol/dm$^3$ of aqueous sodium hydroxide is added to 10 cm$^3$ of 2.0 mol/dm$^3$ of dilute hydrochloric acid.

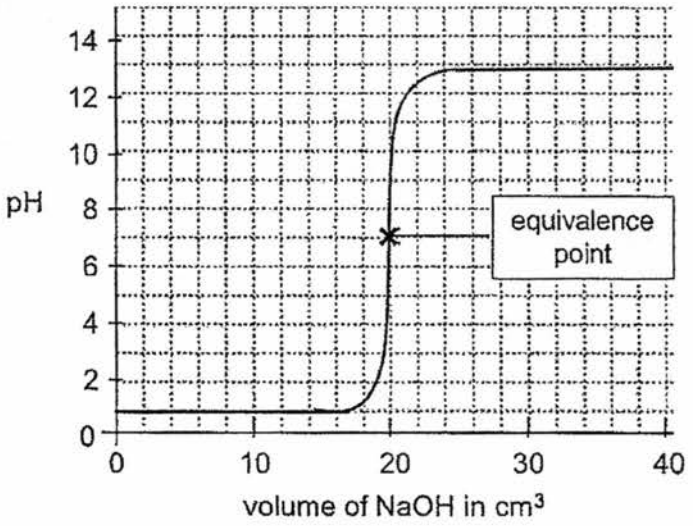



**Fig. 3.1**

The equivalence point is the point where all the hydrogen ions in the acid have reacted with the hydroxide ions in the alkali.

For the neutralization reaction between aqueous sodium hydroxide and dilute hydrochloric acid, the equivalence point occurs at a pH value of 7.

**(a)** With the aid of an ionic equation, explain why the equivalence point for a strong acid-strong base titration occurs at a pH value of 7.

.....

.....

.....[2]

**(b)** Without a pH meter, the progress of the titration can also be monitored using an appropriate indicator, which indicates the end-point of the titration.

Explain why the use of the universal indicator would not be appropriate to monitor the progress of the titration.

.....

.....[1]

**(c)** When a strong alkali is titrated against a weak acid, the equivalence point occurs at a pH value above 7.

The graph below shows the resulting pH curve when 1.0 mol/dm$^3$ of aqueous sodium hydroxide is added to 10 cm$^3$ of 2.0 mol/dm$^3$ of dilute ethanoic acid.

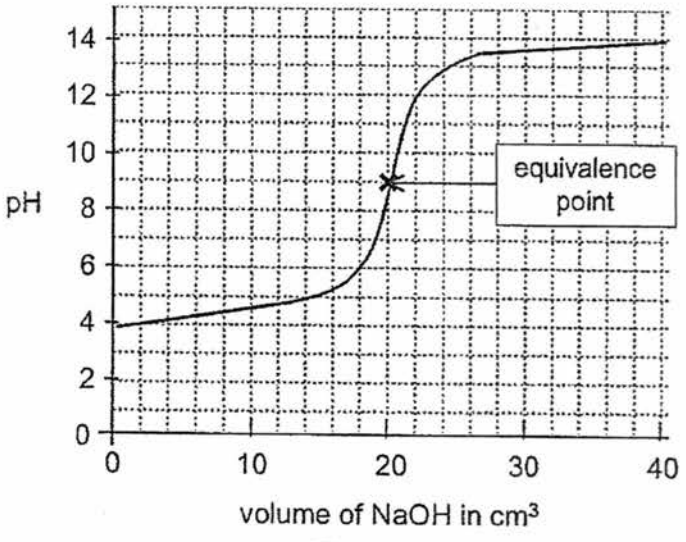



**Fig. 3.2**

**(i)** Write the chemical equation for the reaction between aqueous sodium hydroxide and dilute ethanoic acid. State symbols are not required.

.....[1]

**(ii)** Explain why, in both titration experiments, the equivalence point occurs when 20.0 cm$^3$ of 1.0 mol/dm$^3$ aqueous sodium hydroxide is added.

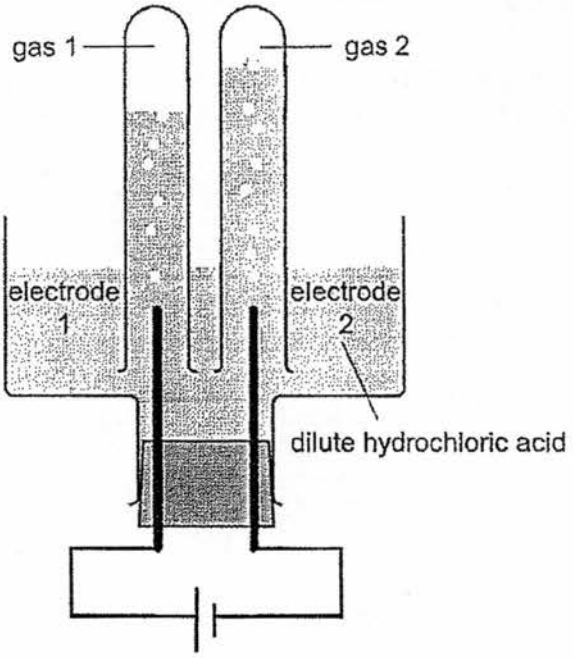
.....

.....

.....

.....[2]

**(d)** The diagram below shows a set-up used to electrolyse dilute hydrochloric acid.




**(i)** Write the half-equations for the reactions occurring at each electrode.

electrode 1:

electrode 2:

[2]

**(ii)** The actual volume of gas 2 collected is less than expected. Suggest a reason for this.

.....

.....[1]

**(iii)** Describe and explain, with the aid of a half-equation, any difference you would expect to observe if the electrolyte was changed to concentrated hydrochloric acid.

.....

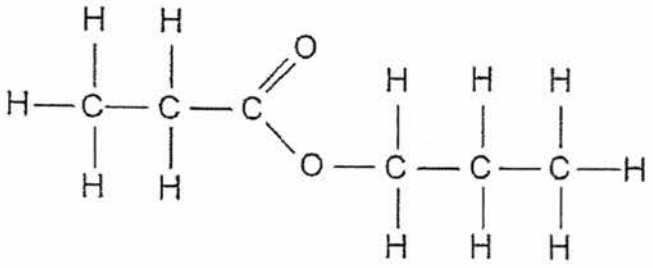
.....

.....

.....[2]

[total = 11 marks]

**A6.** The structure of an ester that is commonly found in pineapples is shown below.



**(a)** Draw the full structural formulae of the alcohol and carboxylic acid used to make this ester.

full structural formula of alcohol:

full structural formula of carboxylic acid:

[2]

**(b)** Besides using litmus or universal indicator, describe another test you could carry out in the laboratory to distinguish the alcohol from the carboxylic acid.

.....

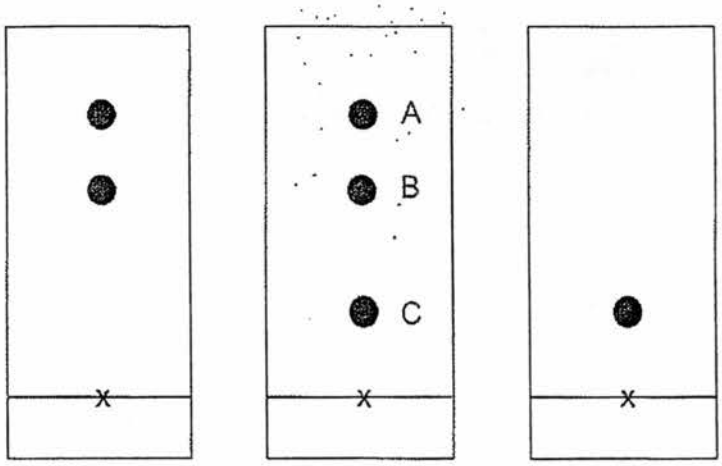
.....

.....

.....[2]

**(c)** The conversion of the alcohol and carboxylic acid into this ester can be monitored using paper chromatography.

A small sample of the reacting mixture was extracted at three separate time intervals and run through the chromatography process. The three chromatograms below show the mixture before the reaction (t = 0 hours), during the reaction (t = 1 hour) and after a long period of time (t = 5 hours).




**(i)** Suggest the identities of the three dots **A**, **B** and **C** on the chromatogram at t = 1 hour, and explain why there are three dots on the chromatogram at this time, compared to t = 0 hours and t = 5 hours.

.....

.....

.....

.....

.....[2]

**(ii)** Make a conclusion about dot **C** based on the results shown in the chromatogram.

.....

.....[1]

[total = 7 marks]

## Section B

Answer all **three** questions in the spaces provided.

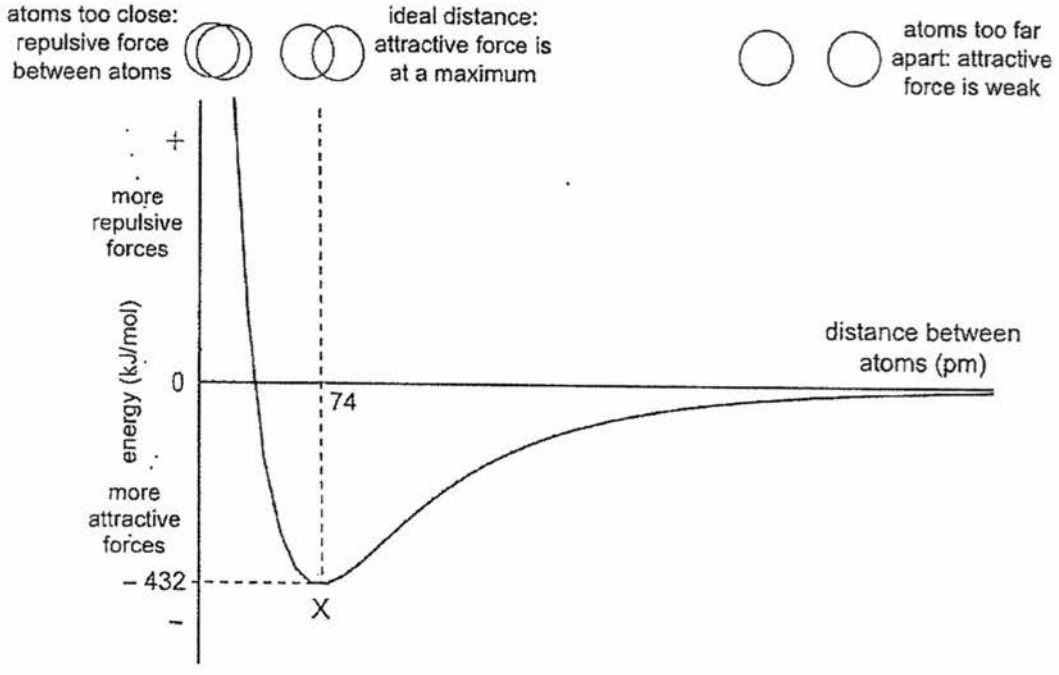
The last question is in the form of an either/or and only one of the alternatives should be attempted.

The total mark for this section is 30.

**B7.** The formation of a covalent bond involves the sharing of electrons between atoms, forming a stable balance between attractive and repulsive forces between the two atoms being bonded.

In a hydrogen molecule, $H_2$, the hydrogen atoms share two electrons via covalent bonding. The bond energy is the amount of energy needed to break one mole of a covalent bond. The bond energy of a H – H bond is 432 kJ/mol.

The graph below shows how the bond energy between the two hydrogen atoms varies with the distance between their nuclei.




A positive energy value means that repulsive forces between the atoms' nuclei are dominant.
A negative energy value means that attractive forces between the atoms' nuclei are dominant.

The bond length is the average distance between the nuclei of two bonded atoms in a molecule where the attractive force is greatest. For a hydrogen molecule, this distance is 74 picometres (pm).

The table below shows how the H–H bond compares with the number of bonds, bond lengths and bond energies of some elements in Period 2.

| type of bond | number of bonds | average bond energy (kJ/mol) | bond length (picometres) |
|---|---|---|---|
| H – H | 1 | 432 | 74 |
| O – O | 1 | 142 | 148 |
| O = O | 2 | 494 | 121 |
| N – N | 1 | 167 | 145 |
| N = N | 2 | 418 | |
| N ≡ N | 3 | 942 | 110 |
| F – F | 1 | 155 | 142 |

**(a)** **(i)** Use the graph to describe how the H–H bond energy changes with the distance between the two hydrogen atoms.

.....

.....

.....

.....

.....

.....[3]

**(ii)** With consideration of how the sub-atomic particles are arranged in an atom, suggest why the bond energy is lowest at 74 picometres.

.....

.....

.....

.....[2]

**(b)** **(i)** Draw dot-and-cross diagrams to show the covalent bonding in nitrogen and fluorine, showing all the electrons.

nitrogen molecule:

fluorine molecule:

[2]

**(ii)** "The greater the number of bonds, the shorter the bond length."

Do you agree with this statement? Use the information in the table to explain your reasoning.

.....

.....

.....

.....

.....

.....[2]

(iii) Use the information in the table to predict the length of the N=N bond.

.....[1]

**(c)** When nitrogen reacts with oxygen to produce nitrogen monoxide, the reaction is endothermic.

The bond energy of the N=O bond is 607 kJ/mol, and the enthalpy change of reaction is +222 kJ/mol.

Explain, in terms of bonds broken and formed, why this reaction is endothermic.

.....

.....

.....

.....[2]

[total = 12 marks]

B8. A metal verifier is an electronic device that can test for precious metals such as gold, silver and platinum. The verifier works by measuring the resistivity (how much each metal opposes the flow of current) of each metal, which is different for each metal and can therefore easily be distinguished.

The table below shows some information about the resistivity of some common materials. The lower the resistivity, the more readily electric current can flow through that metal.

| metal | resistivity (Ωm) at 20 °C |
|---|---|
| carbon (diamond) | $1.00 \times 10^{12}$ |
| carbon (graphite) | |
| gold | $2.44 \times 10^{-8}$ |
| platinum | $1.06 \times 10^{-7}$ |
| silver | $1.59 \times 10^{-8}$ |

**(a)** Using their structures, explain the difference in resistivity between diamond and the three precious metals.

.....

.....

.....

.....

.....[2]

**(b)** Will graphite's resistivity be more similar to the metals or diamond? Briefly explain your reasoning.

.....

.....[1]

**(c)** Precious metals sold commercially often have a purity of about 90-99.9%.

Explain why precious metals are sold commercially in the form of alloys instead of the pure metal.

.....

.....

.....

.....

.....[2]

**(d)** In the table above, the resistivity values are measured at 20 °C.

Using kinetic particle theory, describe and explain how you would expect the resistivity of the materials to change if the temperature was raised to 40 °C.

.....

.....

.....

.....[2]

**(e)** Gold and silver can be extracted from old computers or electronic devices to be recycled and sold commercially.

Describe one advantage of recycling precious metals over mining.

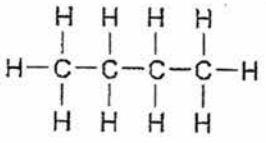
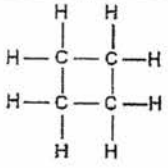
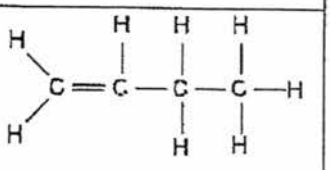
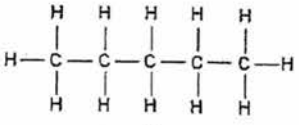
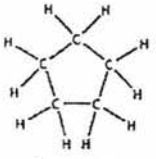
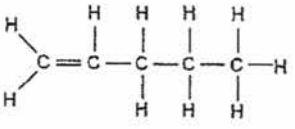
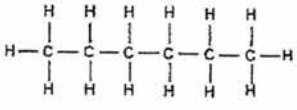
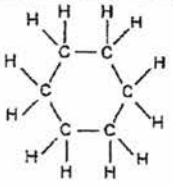
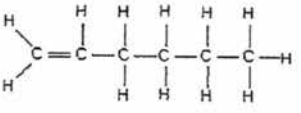
.....

.....[1]

[total = 8 marks]

**EITHER**

**B9.** The table below shows the names and structural formulae of some hydrocarbons.

| number of carbon atoms | alkane | cycloalkane | alkene |
|---|---|---|---|
| 4 |  butane |  cyclobutane |  butene |
| 5 |  pentane |  cyclopentane |  pentene |
| 6 |  hexane |  cyclohexane |  hexene |

**(a)** Explain why pentene and cyclopentane are isomers, but pentane and cyclopentane are not.

.....

.....

.....[2]

**(b)** Do pentene and cyclohexane belong to the same homologous series? Explain your reasoning.

.....

.....[1]

**(c)** A cyclic alkene has the molecular formula of $C_6H_6$. Deduce how many carbon-carbon double bonds $C_6H_6$ has, showing your working clearly.

.....

.....[2]

**(d)** One mole of cyclobutane undergoes an endothermic reaction with one mole of chlorine gas in the presence of UV light.

**(i)** Write the chemical equation for this reaction, showing all the structural formulae of the reactants and products.

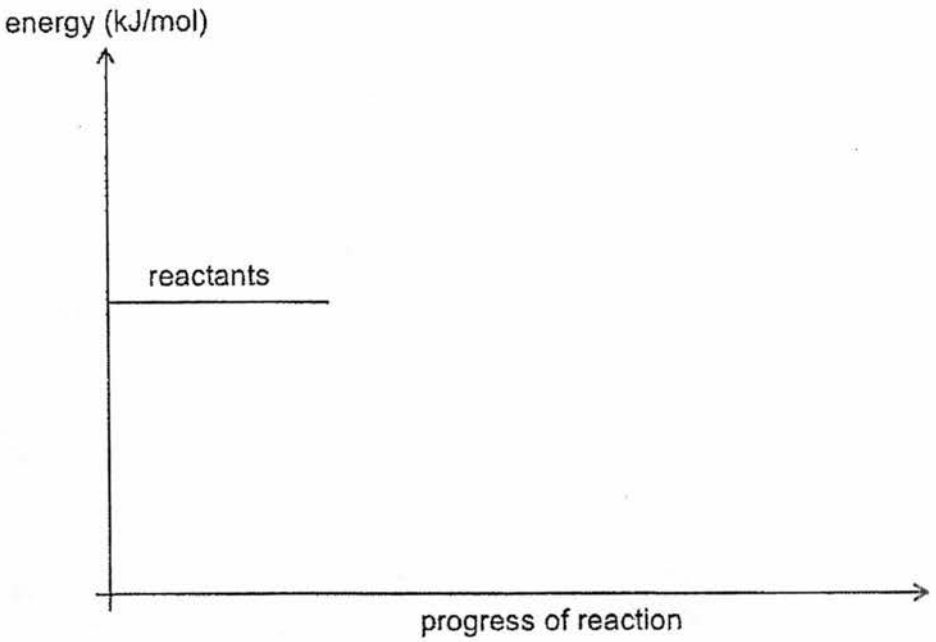
[2]

**(ii)** How would you expect the rate of reaction to change if cyclobutane was reacted with bromine instead? Explain your reasoning.

.....

.....[1]

**(iii)** Draw the energy profile diagram for reaction of cyclobutane and chlorine, labelling the activation energy and enthalpy change for the reaction.

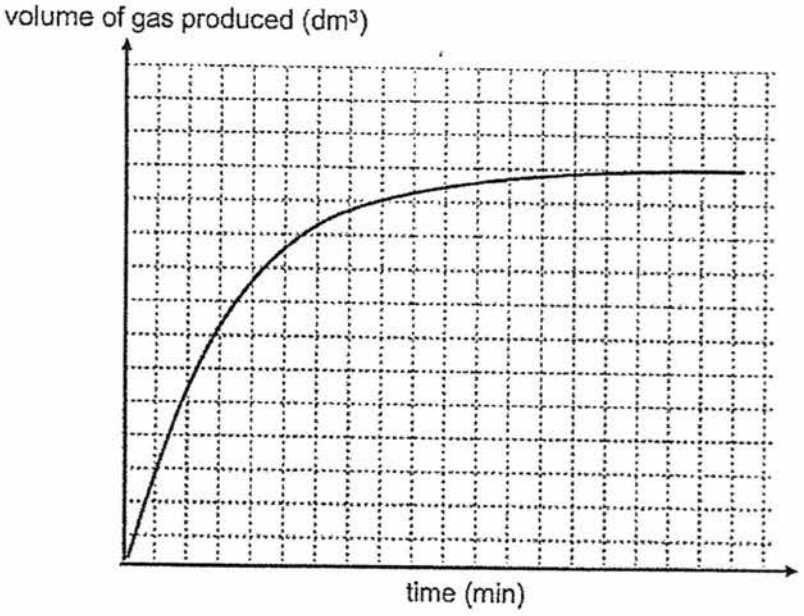



[2]

[total = 10 marks]

OR

**B9.** The reaction between 24 g of magnesium metal and 750 $cm^3$ of 2.00 $mol/dm^3$ sulfuric acid at room temperature and pressure can be monitored in the graph shown below.




**(a)** Write the chemical equation for the reaction. State symbols are not required.

.....[1]

**(b)** Calculate the maximum volume of gas obtained in this reaction at room temperature and pressure.

[3]

**(c)** **(i)** On the same axes, sketch the graph you would obtain if 24 g of zinc metal was used instead. [1]

**(ii)** Describe one variable you would keep constant to ensure that the experiment is fair.

.....

.....[1]

**(d)** When calcium metal is reacted instead, the initial production of gas is the fastest out of the three metals, but the reaction quickly stops.

Explain why this happens.

.....

.....

.....

.....

.....[2]

**(e)** Describe another experiment you could carry out in the laboratory to deduce the order of reactivity of the three metals calcium, magnesium and zinc.

.....

.....

.....

.....

.....

.....[2]

[total = 10 marks]

# The Periodic Table of the Elements

| Group I | Group II | | | | | | | | | | | Group III |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 H hydrogen 1 | | | | | |
| 7 Li lithium 3 | 9 Be beryllium 4 | | | | | | | | | | | 11 B boron 5 |
| 23 Na sodium 11 | 24 Mg magnesium 12 | | | | | | | | | | | 27 Al aluminium 13 |
| 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 |
| 85 Rb rubidium 37 | 88 Sr strontium 38 | 89 Y yttrium 39 | 91 Zr zirconium 40 | 93 Nb niobium 41 | 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 |
| 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 |
| – Fr francium 87 | – Ra radium 88 | – Ac actinium 89 † | | | | | | | | | | |

*58-71 Lanthanoid series
†90-103 Actinoid 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 |
|---|---|---|---|---|---|---|---|---|
| 232 Th thorium 90 | – Pa protactinium 91 | 238 U uranium 92 | – Np neptunium 93 | – Pu plutonium 94 | – Am americium 95 | – Cm curium 96 | – Bk berkellium 97 | – Cf californium 98 |

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

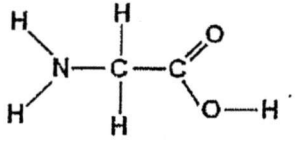
The volume of one mole of any gas is 24 $dm^3$ at room temperature and pressure (r.t.p.).

# ACS(BR) Preliminary Examinations 2017
# Sec 4 Chemistry (5073) Answer Key

PAPER 1

| | | Feedback |
|---|---|---|
| Q1 | C | |
| Q2 | C | |
| Q3 | D | |
| Q4 | A | |
| Q5 | D | |
| Q6 | B | |
| Q7 | B | |
| Q8 | C | |
| Q9 | C | |
| Q10 | D | |
| Q11 | B | |
| Q12 | B | |
| Q13 | B | |
| Q14 | C | |
| Q15 | D | |
| Q16 | A | |
| Q17 | B | |
| Q18 | C | |
| Q19 | D | |
| Q20 | D | |
| Q21 | B | |
| Q22 | B | |
| Q23 | B | |
| Q24 | A | |
| Q25 | D | |
| Q26 | D | |
| Q27 | B | |
| Q28 | D | |
| Q29 | D | |
| Q30 | B | |

<table>
<tr><th colspan="2">Question</th><th>Answer</th></tr>
<tr><td rowspan="6">A1</td><td>(a)</td><td>D and E</td></tr>
<tr><td>(b)</td><td>B</td></tr>
<tr><td>(c)</td><td>B, D and G</td></tr>
<tr><td>(d)</td><td>C and G</td></tr>
<tr><td>(e)</td><td>$PbSiO_3$</td></tr>
<tr><td>(f)</td><td>Add aqueous sodium hydroxide to separate solutions of A and B. [1] A will not produ<br>visible change while B will give a white ppt. that is insoluble in excess sodium hydro<br>OR<br>Add dilute sulfuric acid / any aqueous sulfate salt to separate solutions of A and B. [<br>any ppt./no visible change while B will give a white ppt.. [1] (answers that do not spe<br>salts will not be awarded the first mark)<br>OR<br>Bubble carbon dioxide gas into separate solutions of A and B. [1] A will have no visi<br>will give a white ppt.. [1]</td></tr>
<tr><td rowspan="3">A2</td><td>(a)</td><td>CFCs cause depletion of the ozone layer, causing dangerous exposure to UV rays,</td></tr>
<tr><td>(b)(i)</td><td>No, I do not agree. The size of the CFC is related to its $M_r$, which increases from CH<br>$CCl_2F_2$ ($M_r$ = 121) to $CCl_3F$ ($M_r$ = 137.5). [1]<br>However, the boiling points of the CFCs decreases from $CH_2ClF$ (□9°C) to $CCl_2F_2$ (□<br>increases for $CCl_3F$ (23°C). [1]<br>(boiling points MUST be cited, $M_r$ is not necessary)</td></tr>
<tr><td>(b)(ii)</td><td>
<table>
<tr><td></td><td>C</td><td>Cl</td><td>F</td></tr>
<tr><td>% mass</td><td>11.5</td><td>34</td><td>54.5</td></tr>
<tr><td>$A_r$</td><td>12</td><td>35.5</td><td>19</td></tr>
<tr><td>no. of moles</td><td>0.9583333</td><td>0.9577465</td><td>2.868421</td></tr>
<tr><td>mole ratio</td><td>1</td><td>1</td><td>2.995</td></tr>
</table>
The molecular formula of Freon-13 is $CClF_3$.</td></tr>
</table>

| | | |
|---|---|---|
| | | *(1 mark for each element, full marks awarded only if correct molecular formula is giv* |
| A3 | (a)(i) | This is a redox reaction because nitrogen is reduced as its oxidation state decreases 0 in $N_2$, [1] and carbon is oxidized as its oxidation state increases from +2 in CO to + |
| | (a)(ii) | No, I do not agree. Carbon dioxide is still produced in the catalytic converter, which c warming. |
| | (b) | When the catalyst is powdered, the reacting surface area is larger/greater, [1] resulti frequency of effective collisions, and thus a faster speed/rate of reaction. [1] |
| | (c)(i) | As the amount of air increases, the percentage of CO decreases exponentially to les amount of $NO_2$ initially increases with the amount of air, but later decreases when th air. [1] |
| | (c)(ii) | The more air, the more oxygen present. Hence, the percentage of CO decreases wh oxygen because the CO will react with oxygen to form $CO_2$. (any explanation that ha that less incomplete combustion takes place) [1]<br>The more air, the more oxygen and nitrogen present. Hence, the increased amounts nitrogen will react to produce more $NO_2$. [1]<br>However, when there is a lot of $NO_2$, it will react with the CO present to form $N_2$ and the amount of $NO_2$ to decrease. [1] |
| A4 | (a)(i) |  |
| | (a)(ii) | **Similarity:** both polymers only require one type of monomer / both polymers have gia structures [1]<br>**Difference:** polypropene is a hydrocarbon while polyglycine is not / polyglycine is cor linkage while polypropene is held together by C-C single bonds. [1] |
| | (a)(iii) | no. of moles of $H_2O$ = 990 g ÷ 18 = 55 mol [1]<br>each glycine monomer will produce one small molecule when bonded to another glyc therefore 55 glycine monomers are needed.<br>M. of polyglycine = 55 · 57 = 3135 [1]<br>*(students who write units, penalize one mark overall from Paper 2)* |

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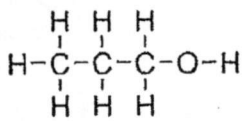
| | (b)(i) | Propene consists of small molecules held together by weak intermolecular forces, [1] much less energy to overcome compared to the strong covalent bonds in the giant m of polypropene. [1] |
| | (b)(ii) | Propene will decolourise the reddish-brown aqueous bromine. [1] When the reaction is only polypropene left, which will have no effect on aqueous bromine. [1]<br>*(answers that simply give two separate outcomes without the idea of monitoring the will get max. 1 mark)* |
| **A5** | (a) | $H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$ [1]<br>All the hydrogen ions in the acid have reacted with all the hydroxide ions in the alkali with the alkali to produce a neutral salt and water only. [1] |
| | (b) | Universal indicator shows a gradient of colours / does not have a distinct colour char values. |
| | (c)(i) | $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$ |
| | (c)(ii) | Since both ethanoic acid and hydrochloric acid are monobasic acids / same number [1] the same number of moles of each acid will require the same volume of sodium h neutralize, given that the concentration is the same / same number of moles of sodiu neutralize (*concept that the mole ratio of acid : alkali is 1:1*). [1] |
| | (d)(i) | electrode 1 (cathode): $2H^+ (aq) + 2e^- \rightarrow H_2 (g)$ [1]<br>electrode 2 (anode): $4OH^- (aq) \rightarrow O_2 (g) + 2H_2O (l) + 4e^-$ [1] |
| | (d)(ii) | Oxygen gas is soluble in water and some dissolves. |
| | (d)(iii) | If concentrated hydrochloric acid is used, chloride ions would be discharged instead gas, so the volume of gas collected at electrode 2 would be the same as at electrode yellow gas is produced instead. [1]<br>$2Cl^- (aq) \rightarrow Cl_2 (g) + 2e^-$ [1] |
| **A6** | (a) | alcohol:<br>  <br>acid: |

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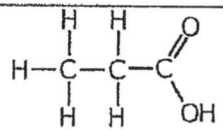
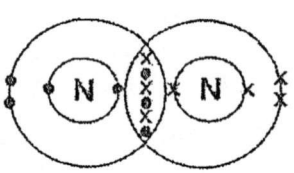
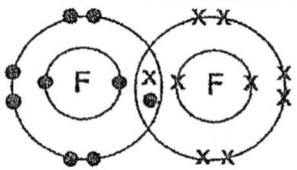
| | |  |
| | (b) | Add the acid and alcohol to separate samples of acidified potassium manganate(VII)<br>The acid will have no effect on the potassium manganate(VII), but the alcohol will ca manganate(VII) to change from purple to colourless. [1]<br>OR<br>Add sodium carbonate or magnesium to separate samples of the alcohol and carbox<br>The acid will have effervescence observed while the alcohol will have no visible char |
| | (c)(i) | At t = 3h, the reaction is not yet complete, [1] so **A** and **B** represent the alcohol and c reactants, while the **C** represents the ester product. [1] |
| | (c)(ii) | Dot C has a larger mass / is heavier / less soluble in the solvent compared to dots A pure / has the lowest Rf value |
| B7 | (a)(i) | When the distance between the two hydrogen atoms increases, the bond energy dec minimum energy of -432 kJ/mol at 74pm [1] When the distance is greater than 74pm, energy increases to almost 0 kJ/mol. [1]<br>*(Answers that only mention positive/negative energy will be awarded max. 2 marks)* |
| | (a)(ii) | At 74pm, there is the greatest attraction [1] of the negatively-charged electrons in one positively-charged protons in the other atom. [1]<br>*(If no mention of negative/positive charges of electrons/protons, or the "greatest" attra mark)* |
| | (b)(i) |  [1]  [1] |
| | (b)(ii) | Do not agree. H-H is a single bond / 1 bond, but the bond length is the lowest at 74pm NαN, where there is a triple bond but the bond length is longer at 110pm. [1]<br>OR<br>Agree. O=O has a double bond / 2 bonds and a longer bond length of 121pm compare 110pm. [1] (any combination is fine, best is to compare between same type of atoms) |

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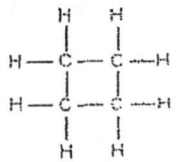
| | | (last mark is for data) |
| | (b)(iii) | Any number between 115 – 135pm (actual value is 125pm) |
| | (c) | There is more energy taken in to break the NαN and O=O bonds [1] than energy giv N-O/N=O bonds. [1] |
| B8 | (a) | Diamond does not conduct electricity because all its electrons are already used in c The three precious metals are able to conduct electricity because they have a 'sea' electrons that can conduct electricity. [1] |
| | (b) | Graphite's resisitivity will be similar to the metals because graphite has mobile elect electricity. |
| | (c) | Pure metals are too soft to be sold commercially / alloys are harder. [1] In alloys, the atoms disrupt the regular arrangement / the layers of atoms do not slide over each |
| | (d) | When the temperature is increased, the electrons/particles (*atoms not accepted*) wil more kinetic energy so the material can conduct electricity better, [1] hence the resis decrease. [1] |
| | (e) | Recycling helps to conserve the finite resource of metals for future use / reduces lar dumping or mining of metals / reduces air and water pollution during mining of meta |
| B9 either | (a) | Pentene and cyclopentane have the same chemical/molecular formula of $C_5H_{10}$, but formula, so they are isomers. [1]<br>Pentane and cyclopentane are not isomers because they do not have the same mo |
| | (b) | No they do not belong to the same homologous series as pentene has the C=C func cyclopentane does not. |
| | (c) | From hexane to hexene, molecular formula changes from $C_6H_{12}$ to $C_6H_{10}$. Every incre results in 2 less H atoms. So from $C_6H_{10}$ to $C_6H_6$, there are 4 less H atoms, so there C=C bonds. Total is 3 C=C double bonds. |
| | (d)(i) |  |
| | (d)(ii) | The rate of reaction between would be slower with bromine because bromine is less |

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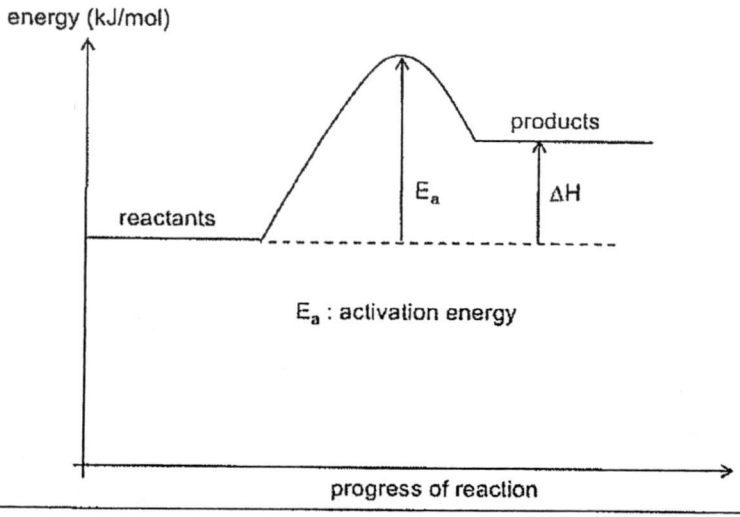
| | | chlorine. |
| | (d)(iii) |  |
| **B9 or** | (a) | $Mg + H_2SO_4 \square MgSO_4 + H_2$ |
| | (b) | no. of moles of Mg = 24 g ⎪ 24 = 1 mol [1]<br>no. of moles of $H_2SO_4$ = 750/1000 · 2 = 1.5 mol [1]<br>Mg is the limiting reagent.<br>volume of $H_2$ = 1 · 24 = 24 $dm^3$ [1] |

| | | |
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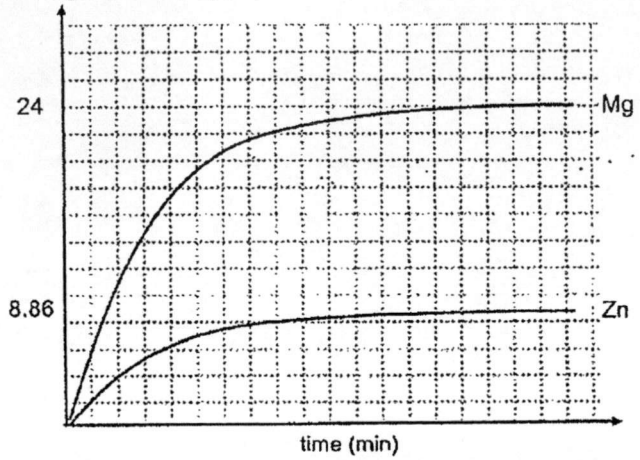
| | (c)(i) | volume of gas produced ($dm^3$)<br>  <br><br>• Graph for Zn must have slower speed, and yield must be slightly more than<br>• No need to label the volumes of gases on the vertical axes; if indicated, ecf f<br>• No need to label Mg and Zn |
| | (c)(ii) | The particle size of each metal / concentration of the acid must be the same. *(Temp accepted because question already stated room temperature and pressure!)* |
| | (d) | Calcium is the most reactive metal compared to magnesium and zinc, so it will react sulfuric acid. [1] However, the reaction quickly stops because an insoluble layer of c around the metal, preventing further reaction. [1] |
| | (e) | React the three metals separately with <u>cold water</u>. [1]<br>Calcium is the most reactive so it will have the most vigorous effervescence, followe with less effervescence. Zinc will not have any effervescence at all. **OR**<br>Measure the volume of hydrogen gas produced within the same period of time. Calc most gas first, followed by magnesium. Zinc will not produce any gas at all. [1] |