Name: ..... (  ) Class: Sec 4 SG 1 / 2

# Queenstown Secondary School

**Preliminary Examination 2024**
**Secondary Four Express**
**Chemistry**
**6092/01**

**28 August 2024**
**Wednesday**

**Time: 1145 – 1245h**
**Duration: 1 hour**

**Setter:**

**Additional Materials:** Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

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

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

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 21.
The use of an approved scientific calculator is expected, where appropriate.

1 The reaction of manganate(VII) ions with ethanedioate ions in acid solution may be represented by the following equation.

$$2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

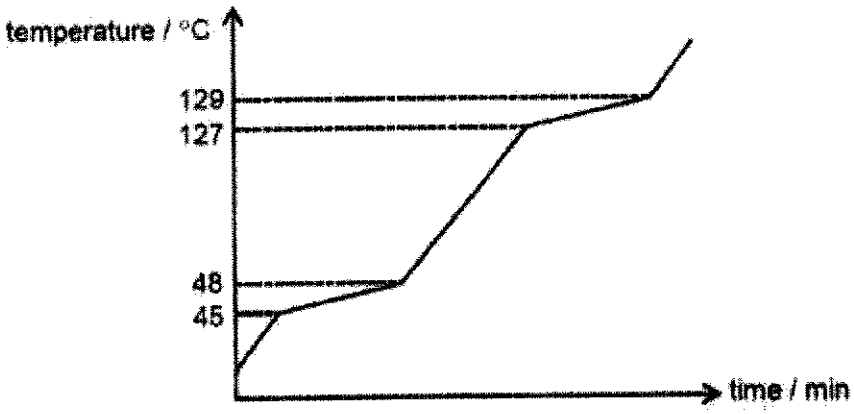
A student is exploring various ways to measure the rate of the reaction by measuring changes in different variables of the reaction.

Which of the following methods of monitoring the rate of reaction are suitable?

1 volume of gas produced
2 pH of the reaction mixture
3 mass of the reaction mixture
4 amount of precipitate obtained
5 intensity of the purple colour of the reaction mixture

**A** 1, 2 and 3 **B** 1, 3 and 4 **C** 1, 2, 3 and 5 **D** 2, 3, 4 and 5

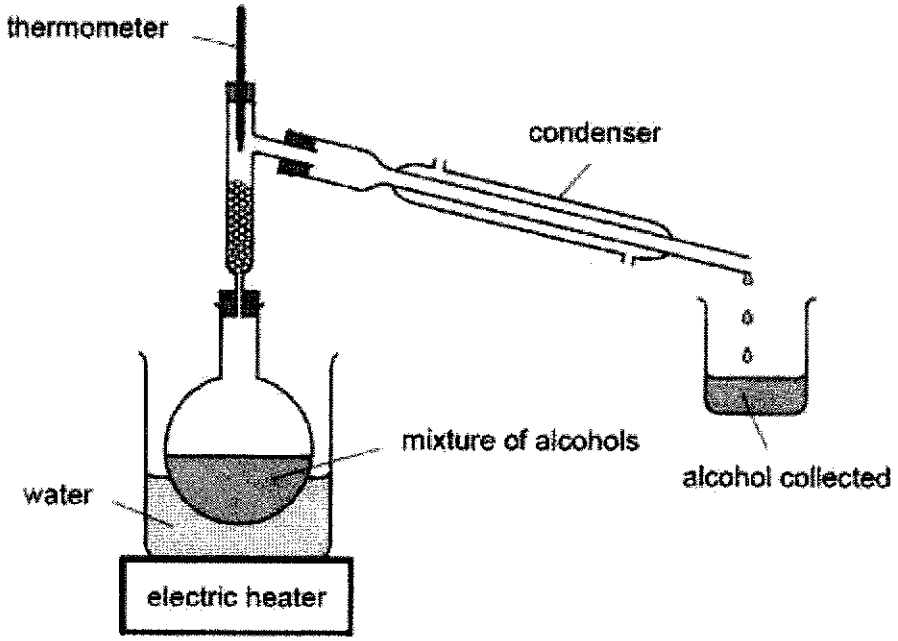
2 The heating curve of an impure sample of substance X is shown below.




What are the melting point and boiling point of pure substance X?

| | melting point / °C | boiling point / °C |
|---|---|---|
| **A** | 45 | 129 |
| **B** | 47 | 128 |
| **C** | 48 | 127 |
| **D** | 49 | 130 |

3 A student carried out an experiment using the set-up shown below to separate a mixture containing four alcohols.




The table gives the boiling points of the four alcohols used.

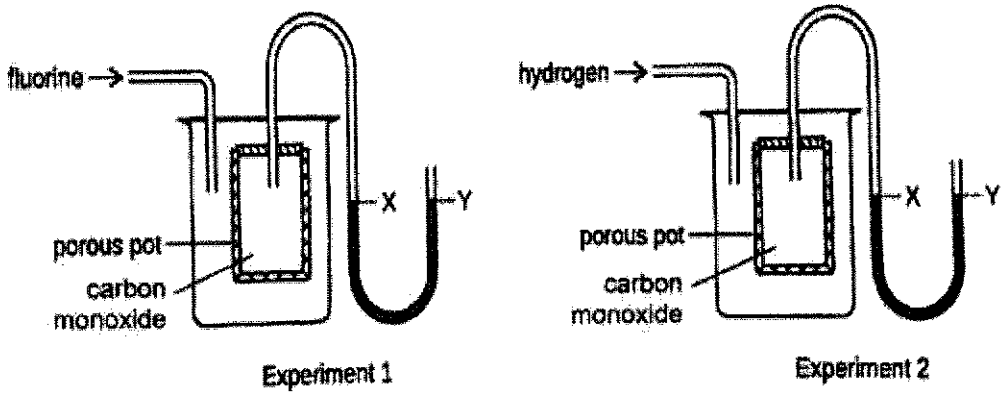
| alcohol | butanol | ethanol | pentanol | propanol |
|---|---|---|---|---|
| boiling point / °C | 117 | 79 | 138 | 97 |

Despite repeated attempts, the student only managed to obtain two alcohols from the mixture.

Which alcohols did he fail to obtain?

**A** butanol and ethanol
**B** butanol and pentanol
**C** ethanol and propanol
**D** pentanol and propanol

4 Two experimental set-ups used to demonstrate the diffusion of gases are shown in the diagrams below. In each porous pot is carbon monoxide.
In the first experiment, the gas introduced into the beaker is fluorine gas, while in the second experiment, hydrogen gas was introduced.



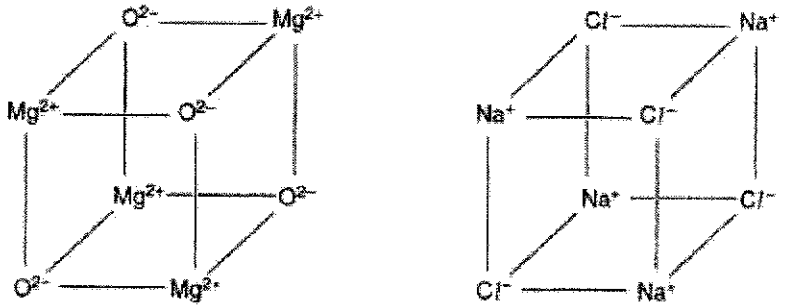

What changes, if any, to the water levels X and Y would you expect to see in both experiments?

| | experiment 1 | experiment 2 |
|---|---|---|
| **A** | Y is higher than X | X is higher than Y |
| **B** | X is higher than Y | Y is higher than X |
| **C** | X and Y remain the same | Y is higher than X |
| **D** | X and Y remain the same | X and Y remain the same |

5 An ion, $X^{2-}$, has a mass number of m and it contains n electrons.
What does the nucleus of an atom of X contain?

| | number of protons | number of neutrons |
|---|---|---|
| **A** | n – 2 | m – n |
| **B** | n – 2 | m – n + 2 |
| **C** | n + 2 | m – n + 2 |
| **D** | n + 2 | m – n – 2 |

6 Part of the giant lattice structure of magnesium oxide and sodium chloride is shown.

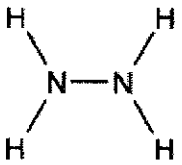



The structure repeats to make a giant lattice.

In the giant lattice, how many negative ions directly surround each positive ion?

**A** 3 **B** 4 **C** 5 **D** 6

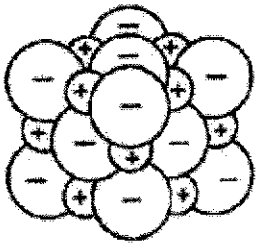
7 The diagram shows the structural formula of the covalent molecule hydrazine, $N_2H_4$.



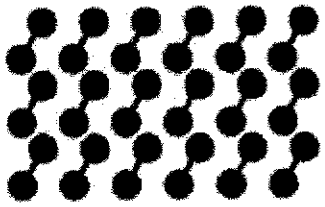

Which row is correct?

| | total number of electrons involved in bonding | total number of electrons **not** involved in bonding |
|---|---|---|
| **A** | 5 | 4 |
| **B** | 5 | 8 |
| **C** | 10 | 4 |
| **D** | 10 | 8 |

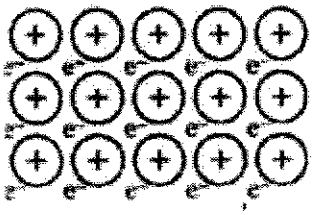
8 The structures of three substances P, Q and R are shown below.



P



Q



R

Which statements are correct?

1 P and R can conduct electricity in the molten state.
2 Q is an element while P and R are compounds.
3 P has a giant structure while Q has a simple structure.

**A** 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1, 2 and 3

9 The information below shows the percentage of carbon in two samples of steel, Q and R. Q consists of 60% carbon while R consists of 20% carbon.

Which statement is correct about the two samples of steel?

**A** Q has higher strength and less brittle than R.
**B** R has higher strength and more brittle than Q.
**C** Q has lower strength and more brittle than R.
**D** R has lower strength and less brittle than Q.

10 Upon strong heating, a metal nitrate compound undergoes decomposition according to the following equation:

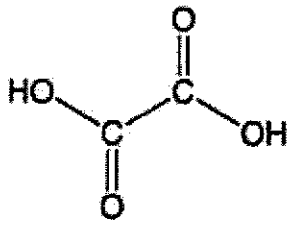
$$2XNO_3\,(s) \rightarrow 2X\,(s) + 2NO_2\,(g) + O_2\,(g)$$

Complete decomposition of 3.40 g of the nitrate gives 240 $cm^3$ of oxygen, measured at room temperature and pressure.

What is the relative atomic mass of X?

**A** 85 **B** 108 **C** 133 **D** 170

**11** The structure of oxalic acid is shown.




A 25.0 $cm^3$ solution of oxalic acid reacts completely with 15.0 $cm^3$ of 2.50 $mol/dm^3$ aqueous sodium hydroxide.

What is the concentration of the oxalic acid?

**A** 0.750 $mol/dm^3$ **B** 2.08 $mol/dm^3$ **C** 1.50 $mol/dm^3$ **D** 4.17 $mol/dm^3$

**12** Aspirin, $C_9H_8O_4$, is made from salicylic acid, $C_7H_6O_3$ according to the equation:

$$C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + CH_3COOH$$

Assuming a 70% yield, what is the mass of salicylic acid required to make an aspirin tablet of 325 mg?

[$M_r$: $C_7H_6O_3$, 138; $C_9H_8O_4$, 180]

**A** 174 mg **B** 249 mg **C** 356 mg **D** 424 mg

**13** 50.0 $cm^3$ of hydrochloric acid has a pH of 1.0.
This acid requires 25.0 $cm^3$ of aqueous sodium hydroxide to be neutralised.
A second 50.0 $cm^3$ solution contains the weak acid, ethanoic acid.
The hydrochloric acid and ethanoic acid have the same concentration.

How will the pH of ethanoic acid and the volume of NaOH needed for neutralisation differ, if at all, from the hydrochloric acid?

| | pH | volume of NaOH needed for neutralisation |
|---|---|---|
| **A** | higher than HC*l* | lower than for HC*l* |
| **B** | higher than HC*l* | equal to HC*l* |
| **C** | lower than HC*l* | lower than for HC*l* |
| **D** | lower than HC*l* | equal to HC*l* |

14 What is a characteristic property of all bases?

**A** Alkalis are bases which are insoluble in water.
**B** They dissolve in water to produce hydroxide ions.
**C** They form salts with acids.
**D** They react with ammonia to form ammonium salts.

15 Which statements about oxides are correct?

1 An aqueous solution of sulfur dioxide has a pH less than 7.
2 An aqueous solution of potassium oxide turns blue litmus paper red.
3 Carbon dioxide reacts with ammonia to make a salt.
4 Carbon monoxide reacts with hydrochloric acid to make a salt.

**A** 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 3 and 4

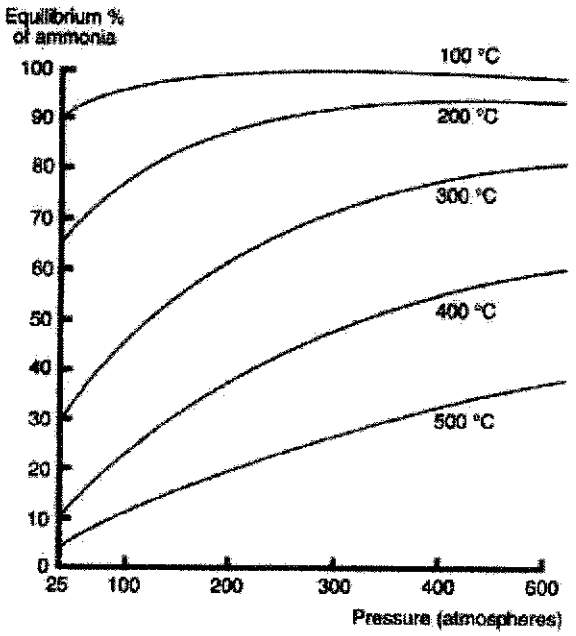
16 Which of the following method could **not** be used to prepare a dry sample of lead salt?

| | name of salt | method |
|---|---|---|
| **A** | lead(II) carbonate | add aqueous sodium carbonate to aqueous lead(II) nitrate |
| **B** | lead(II) chloride | add hydrochloric acid to aqueous lead(II) nitrate |
| **C** | lead(II) iodide | add nitric acid to lead(II) carbonate, then add aqueous potassium iodide |
| **D** | lead(II) sulfate | add sulfuric acid to lead(II) carbonate |

**17** Ammonia is produced from Haber Process using a suitable catalyst.

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$$

The following graph shows the different yields of ammonia at different temperature and pressure.




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

**A** A higher percentage yield of ammonia can be obtained at higher pressure.

**B** A higher percentage yield of ammonia can be obtained at lower temperature.

**C** Some of the ammonia formed will decompose to form hydrogen and nitrogen.

**D** At the right conditions of temperature and pressure, all of the hydrogen and nitrogen can be converted into ammonia.

**18** Three tests are carried out on salt X.

| S/N | test | result |
|---|---|---|
| 1 | To 2 $cm^3$ of salt X, add aqueous sodium hydroxide until no further change. Warm the mixture. Keep the mixture for Test 4. | White precipitate, soluble in excess giving a colourless solution. |
| 2 | To 2 $cm^3$ of salt X, add aqueous ammonia until no further change. | White precipitate, soluble in excess giving a colourless solution. |
| 3 | To 2 $cm^3$ of salt X, add dilute nitric acid followed by aqueous silver nitrate. | No visible reaction. |
| 4 | To 2 $cm^3$ of the mixture in test 1, add aluminium foil. | Gas evolved turns damp litmus paper blue. |

What is the identity of salt X?

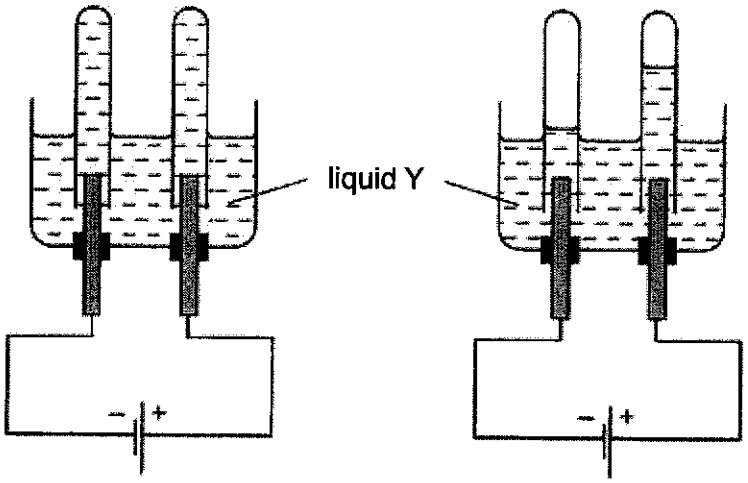
**A** aluminium chloride
**B** ammonium nitrate
**C** zinc chloride
**D** zinc nitrate

**19** A disproportionation reaction occurs when the same element undergoes both oxidation and reduction simultaneously in a chemical reaction.

Which of the following is **not** a disproportionation reaction?

**A** $Mg + FeCl_2 \rightarrow MgCl_2 + Fe$
**B** $H_2SO_4 + Cu_2O \rightarrow Cu + CuSO_4 + H_2O$
**C** $2H_2O_2 \rightarrow O_2 + 2H_2O$
**D** $2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$

**20** The diagrams show an electrolysis set-up using inert electrodes.

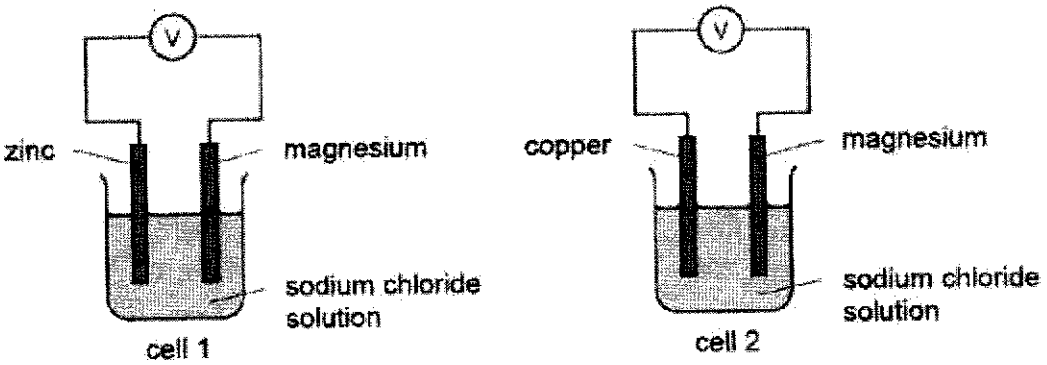



Which could be liquid Y?

1 aqueous magnesium nitrate
2 aqueous copper(II) sulfate
3 concentrated hydrochloric acid
4 dilute sulfuric acid

**A** 1 and 4 only **B** 2 and 4 only **C** 1, 2 and 4 only **D** 1, 3 and 4 only

21 A student set up two simple cells as shown below.




He recorded four statements in his notebook.

statement 1: In cell 1, sodium ions gain electrons to form sodium.

statement 2: In cell 2, copper(II) ions gain electrons to form copper.

statement 3: In both cells, magnesium loses electrons to form magnesium ions.

statement 4: The voltage of cell 1 is greater than cell 2.

Which statements are **incorrect**?

**A** 1 and 2 **B** 1 and 4 **C** 1, 2 and 4 **D** 2, 3 and 4

22 Which statement regarding the Periodic Table is correct?

**A** The elements are arranged by increasing relative atomic mass.

**B** Across a period from left to right, elements have weaker reducing power.

**C** Down Group 1, the elements become stronger oxidising agents.

**D** Down Group 17, the elements become weaker reducing agents.

23 Excess bromine is shaken with a mixture of sodium chloride and sodium iodide solutions. Which substances will the final mixture contain?

**A** bromine, iodine, sodium bromide

**B** bromine, iodine, sodium bromide, sodium chloride

**C** bromine, iodine, sodium bromide, sodium iodide

**D** iodine, sodium bromide, sodium chloride

**24** The properties of the element vanadium, V, can be predicted from its position in the Periodic Table.

Which row identifies the properties of vanadium?

| | can be used as a catalyst | conducts electricity at r.t.p. | forms coloured compounds | has a low density |
|---|---|---|---|---|
| **A** | ✓ | ✓ | ✓ | × |
| **B** | ✓ | ✓ | × | ✓ |
| **C** | ✓ | × | ✓ | ✓ |
| **D** | × | ✓ | ✓ | ✓ |

[key: ✓ = yes; × = no]

**25** The table below shows three unknown metals and their method of extraction.

| metal | method of extraction |
|---|---|
| P | reduction of ore by carbon |
| Q | electrolysis |
| R | mining from the ground |

Which statement regarding the three metals is true?

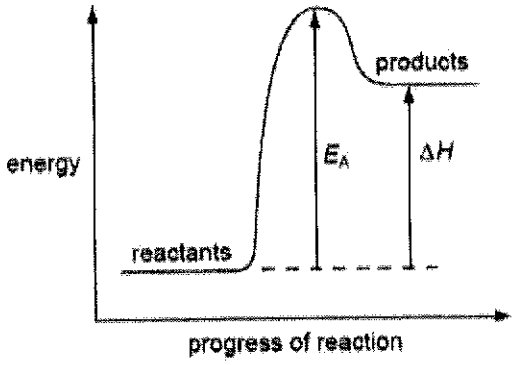
**A** Metal Q should be found high up in the reactivity series.

**B** Metal R is most likely to be found above hydrogen in the reactivity series.

**C** Metal R is the most reactive metal among all three.

**D** The oxide of P must be the most stable compared to the oxides of the other two metals.

**26** The diagram shows the energy profile for a chemical reaction.




What is the correct description of the reaction?

| | sign of $E_A$ | sign of $\Delta H$ | overall energy change |
|---|---|---|---|
| **A** | - | - | exothermic |
| **B** | + | + | endothermic |
| **C** | - | + | endothermic |
| **D** | + | + | exothermic |

**27** Methane burns in excess oxygen to produce carbon dioxide and water.

$$CH_4\,(g) + 2O_2\,(g) \rightarrow CO_2\,(g) + 2H_2O\,(g)$$

Given the following information of the bond energies, calculate the enthalpy change of the reaction.

| bond | C — H | O = O | C = O | O – H |
|---|---|---|---|---|
| bond energy / $kJmol^{-1}$ | 410 | 496 | 805 | 460 |

**A** –359 kJ/mol **B** –818 kJ/mol **C** +102 kJ/mol **D** +818 kJ/mol

**28** In which reaction is pressure **least** likely to affect the rate of reaction?

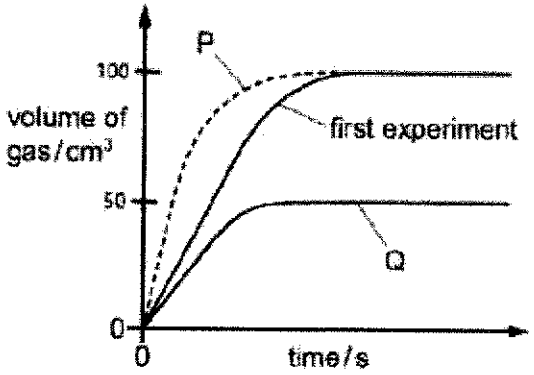
**A** $N_2\,(g) + 3H_2\,(g) \rightarrow 2NH_3\,(g)$

**B** $HCl\,(g) + NH_3\,(g) \rightarrow NH_4Cl\,(s)$

**C** $CO_2\,(g) + Ca(OH)_2\,(aq) \rightarrow CaCO_3\,(s) + H_2O\,(l)$

**D** $K_2CO_3\,(s) + H_2SO_4\,(aq) \rightarrow K_2SO_4\,(aq) + H_2O\,(l) + CO_2\,(g)$

29 In the first experiment, excess magnesium reacts with 25 $cm^3$ of 1.0 $mol/dm^3$ hydrochloric acid to produce hydrogen gas. The volume of hydrogen produced is measured and shown in the graph.




Graphs P and Q show the volume of hydrogen produced under different conditions. What changes in conditions produce graphs P and Q?

**A** P uses a higher temperature and Q uses a lower temperature.

**B** P uses 25 $cm^3$ of 1.5 $mol/dm^3$ hydrochloric acid and Q uses 25 $cm^3$ of 0.5 $mol/dm^3$ hydrochloric acid.

**C** P uses a catalyst and Q uses 25 $cm^3$ of 0.5 $mol/dm^3$ hydrochloric acid.

**D** P uses smaller strips of magnesium of the same mass and Q uses a lower temperature.

30 The table shows the boiling points of four fractions P, Q, R and S, obtained when crude oil is distilled.

| fraction | boiling point range / °C |
|---|---|
| P | 35 – 75 |
| Q | 80 – 145 |
| R | 150 – 250 |
| S | > 250 |

How is fraction P different from fraction S?

**A** Fraction P is in less demand than S.

**B** Fraction P is more viscous than fraction S.

**C** Fraction P is more flammable than fraction S.

**D** Fraction P contains molecules of larger relative molecular masses than fraction S.

31 Biodiesel, an alternative fuel made from vegetable oil, can be used as a fuel for vehicles. Although carbon dioxide is released during the combustion of biodiesel, scientists still claim that it is a carbon neutral fuel.

Which is the basis for this claim?

**A** Biodiesel is not a carbon compound.

**B** Biodiesel produces less carbon dioxide when it burns.

**C** Plants release carbon dioxide during respiration.

**D** Plants absorb carbon dioxide during photosynthesis.

32 Pentane, $C_5H_{12}$, and octane, $C_8H_{18}$, are alkanes present in the petrol fraction.

Which statements about alkanes are correct?

1 They are unsaturated hydrocarbons.

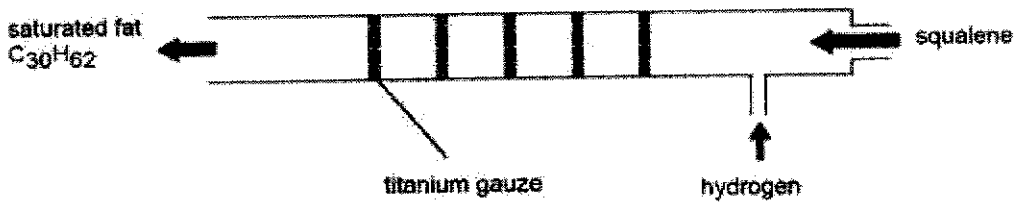
2 Their general formula is $C_nH_{2n+2}$.

3 Pentane has a higher boiling point than octane.

4 Both pentane and octane undergo substitution reaction with chlorine in the presence of light.

**A** 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

33 Squalene, a naturally occurring polyunsaturated oil present in sharks can be reduced to form a saturated hydrocarbon using titanium as a catalyst.

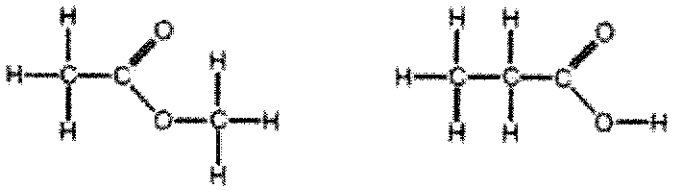



A 0.100 mol sample of squalene reacted with 14.4 $dm^3$ of hydrogen at room temperature and pressure to form a saturated hydrocarbon, $C_{30}H_{62}$.

What is the molecular formula of squalene?

**A** $C_{30}H_{50}$ **B** $C_{30}H_{52}$ **C** $C_{30}H_{54}$ **D** $C_{30}H_{56}$

**34** The displayed formulae of two compounds are shown.



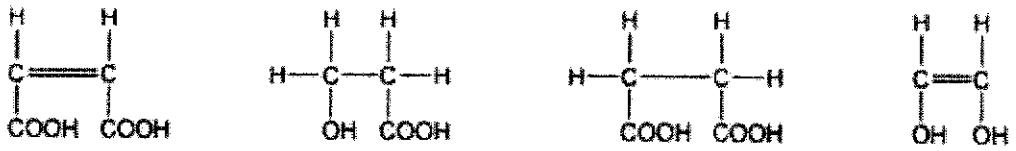
Which statement(s) about the compounds is/are correct?

1 Both compounds are from the same homologous series.
2 Both compounds have the same molecular formula.
3 Both compounds have the same percentage mass of carbon.
4 Both compounds undergo the same type of reactions.

**A** 1 and 2 only **B** 1 and 4 only **C** 2 and 3 only **D** 3 and 4 only

**35** The structures of compounds W, X, Y and Z are shown below.

W X Y Z



What reactions do compounds W, X, Y and Z undergo?

| | decolourises aqueous bromine | decolourises acidified aqueous potassium manganate(VII) | effervescence with aqueous sodium carbonate |
|---|---|---|---|
| **A** | X and Y | X and Z | W and Y |
| **B** | X and Y | W, X and Y | W and Y |
| **C** | W and Z | X and Z | W, X and Y |
| **D** | W and Z | W, X and Y | W, X and Y |

**36** Two esters have the same molecular formula, $C_3H_6O_2$.

What are the names of these two esters?

1 methyl ethanoate
2 ethyl methanoate
3 ethyl propanoate
4 propyl methanoate

**A** 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 3 and 4

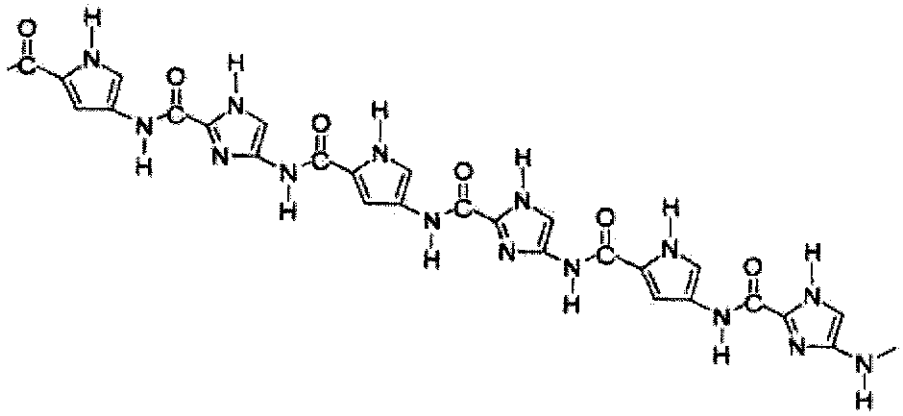
**37** Engine oil is used to lubricate the car engine. Certain polymers are added to improve the viscosity of engine oil. A portion of the chain of one such polymer is shown below.

$$-CH_2-CH(CH_2CH_2CH_3)-CH_2-CH(CH_2CH_2CH_3)-CH_2-CH(CH_2CH_2CH_3)-$$

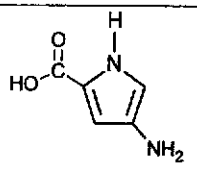
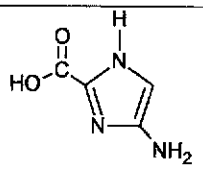
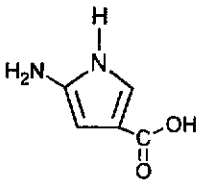
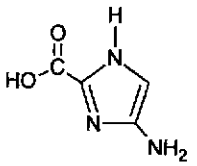
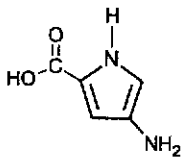
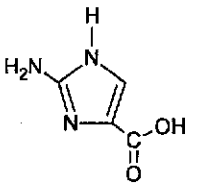
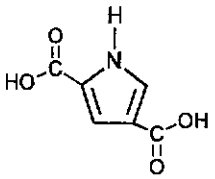
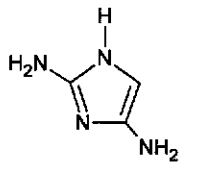
A molecule of this polymer contains 40 carbon atoms. How many molecules of monomer are required to form one molecule of this polymer?

**A** 4 **B** 5 **C** 8 **D** 10

**38** The structure below shows part of a polymer.



Which one of the following options show the correct monomers?

| | | |
|---|---|---|
| **A** |  |  |
| **B** |  |  |
| **C** |  |  |
| **D** |  |  |

**39** A sample of air is slowly passed through aqueous sodium hydroxide and then over heated copper. Which gases are removed by this process?

**A** carbon dioxide and water vapour
**B** carbon dioxide and oxygen
**C** nitrogen and oxygen
**D** nitrogen and water vapour

**40** Nitrogen monoxide, NO, is formed in the engines of petrol-powered cars. One constituent of petrol is pentane, $C_5H_{12}$. Nitrogen monoxide is removed from exhaust fumes by catalytic converters.

Which row identifies the reactants that produce nitrogen monoxide and a reaction that removes it in the catalytic converter?

| | reactants that produce NO | reaction that removes NO |
|---|---|---|
| **A** | pentane + one gas found in air | $NO + CO \rightarrow \frac{1}{2}N_2 + CO_2$ |
| **B** | pentane + one gas found in air | $NO + CO_2 \rightarrow NO_2 + CO$ |
| **C** | two gases found in air | $NO + CO \rightarrow \frac{1}{2}N_2 + CO_2$ |
| **D** | two gases found in air | $NO + CO_2 \rightarrow NO_2 + CO$ |

# The Periodic Table of Elements

| Group | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | | | | | | | | | | 13 | 14 | 15 | 16 | 17 | 18 |
| | | | | | | | 1 H hydrogen 1 | | | | | | | | | | 2 He helium 4 |
| 3 Li lithium 7 | 4 Be beryllium 9 | Key: proton (atomic) number; atomic symbol; name; relative atomic mass | | | | | | | | | | 5 B boron 11 | 6 C carbon 12 | 7 N nitrogen 14 | 8 O oxygen 16 | 9 F fluorine 19 | 10 Ne neon 20 |
| 11 Na sodium 23 | 12 Mg magnesium 24 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 Al aluminium 27 | 14 Si silicon 28 | 15 P phosphorus 31 | 16 S sulfur 32 | 17 Cl chlorine 35.5 | 18 Ar argon 40 |
| 19 K potassium 39 | 20 Ca calcium 40 | 21 Sc scandium 45 | 22 Ti titanium 48 | 23 V vanadium 51 | 24 Cr chromium 52 | 25 Mn manganese 55 | 26 Fe iron 56 | 27 Co cobalt 59 | 28 Ni nickel 59 | 29 Cu copper 64 | 30 Zn zinc 65 | 31 Ga gallium 70 | 32 Ge germanium 73 | 33 As arsenic 75 | 34 Se selenium 79 | 35 Br bromine 80 | 36 Kr krypton 84 |
| 37 Rb rubidium 85 | 38 Sr strontium 88 | 39 Y yttrium 89 | 40 Zr zirconium 91 | 41 Nb niobium 93 | 42 Mo molybdenum 96 | 43 Tc technetium – | 44 Ru ruthenium 101 | 45 Rh rhodium 103 | 46 Pd palladium 106 | 47 Ag silver 108 | 48 Cd cadmium 112 | 49 In indium 115 | 50 Sn tin 119 | 51 Sb antimony 122 | 52 Te tellurium 128 | 53 I iodine 127 | 54 Xe xenon 131 |
| 55 Cs caesium 133 | 56 Ba barium 137 | 57–71 lanthanoids | 72 Hf hafnium 178 | 73 Ta tantalum 181 | 74 W tungsten 184 | 75 Re rhenium 186 | 76 Os osmium 190 | 77 Ir iridium 192 | 78 Pt platinum 195 | 79 Au gold 197 | 80 Hg mercury 201 | 81 Tl thallium 204 | 82 Pb lead 207 | 83 Bi bismuth 209 | 84 Po polonium – | 85 At astatine – | 86 Rn radon – |
| 87 Fr francium – | 88 Ra radium – | 89–103 actinoids | 104 Rf rutherfordium – | 105 Db dubnium – | 106 Sg seaborgium – | 107 Bh bohrium – | 108 Hs hassium – | 109 Mt meitnerium – | 110 Ds darmstadtium – | 111 Rg roentgenium – | 112 Cn copernicium – | 113 Nh nihonium – | 114 Fl flerovium – | 115 Mc moscovium – | 116 Lv livermorium – | 117 Ts tennessine – | 118 Og oganesson – |

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

The volume of one mole of any gas is 24 $dm^3$ at room temperature and pressure (r.t.p.)
The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$.

Name: ..... (  ) Class: Sec 4 SG 1 / 2

# Queenstown Secondary School

**Preliminary Examination 2024**
**Secondary Four Express**
**Chemistry**
**6092/02**

**20 August 2024**
**Tuesday**

**Time: 1115 – 1300h**
**Duration: 1 hour 45 minutes**

**Setter:**

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

**READ THESE INSTRUCTIONS FIRST**

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

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

**Section B**
Answer **one** question.
Write your answers in the spaces provided.

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

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

| Examiner's Use | |
|---|---|
| Section A | /70 |
| Section B | /10 |
| B9 | |
| B10 | |
| TOTAL | /80 |

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

## Section A

Answer **all** questions.

**A1** Use the list of substances to answer the questions.

| | | |
|---|---|---|
| **calcium hydroxide** | **carbon monoxide** | **copper** |
| **hydrogen** | **magnesium** | **nitrogen** |
| **nitrogen dioxide** | **sulfur dioxide** | **zinc oxide** |

Each substance can be used once, more than once or not at all.

Name the substance(s) which

**(a)** is added to soil to increase the pH,

..... [1]

**(b)** helps prevent iron in underwater pipes from rusting,

..... [1]

**(c)** lead to the formation of acid rain that corrodes limestone buildings,

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

**(d)** react in a 1:3 ratio in the Haber Process to produce ammonia.

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

[Total: 4]



**[Turn over**

**A2** Esters are commercially used as solvents for cosmetics, perfumes and glue.

**(a)** Propyl ethanoate has a characteristic odour of pears and is commonly used in fragrances. A bottle of perfume containing propyl ethanoate is left opened in a laboratory and it diffused throughout the laboratory.

**(i)** Give the names and draw the full structural formulae of the carboxylic acid and the alcohol that react to form propyl ethanoate.

..... ..... [2]

**(ii)** The temperature of the laboratory is increased.

Explain, in terms of collisions between reacting particles, what effect would this have on the rate of diffusion of propyl ethanoate.

.....

.....

..... [2]

**(b)** The table shows some information about different esters.

**Table 2**

| name | formula | relative molecular mass |
|---|---|---|
| methyl methanoate | $HCO_2CH_3$ | 60 |
| ethyl methanoate | $HCO_2C_2H_5$ | 74 |
| propyl methanoate | $HCO_2C_3H_7$ | 88 |
| butyl methanoate | $HCO_2C_4H_9$ | 102 |
| pentyl methanoate | $HCO_2C_5H_{11}$ | 116 |

(i) Use information in the table to give **one** piece of evidence that suggests that the esters belong to the same homologous series.

.....

..... [1]

(ii) Which ester has the greatest rate of diffusion at room temperature and pressure? Explain your answer.

.....

.....

..... [2]

[Total: 7]

**A3** Seawater constitutes a rich source of various commercially important elements.

**(a)** Magnesium bromide is an important salt found in seawater.

Table 3 shows some information about two isotopes of bromine.

**Table 3**

| symbol | number of protons | number of neutrons | number of electrons |
|---|---|---|---|
| $^{79}_{35}Br$ | 35 | | 35 |
| $^{81}_{35}Br^-$ | | 46 | |

(i) Complete the table. [1]

(ii) Use data from the table to explain the term *isotopes*.

.....

..... [1]

(iii) Chlorine is treated with a sample of seawater containing magnesium bromide.

Write the ionic equation for the reaction that occurs.

..... [1]

(iv) Explain why astatine does not react with aqueous magnesium bromide.

.....

..... [1]

(b) The distinctive smell of the seaside was thought to be due to ozone ($O_3$).

Ozone reacts with aqueous potassium iodide as shown in the equation below.

$$2I^-(aq) + O_3(g) + 2H^+(aq) \rightarrow I_2(aq) + O_2(g) + H_2O(l)$$

(i) Describe what is observed when ozone is bubbled into aqueous potassium iodide.

..... [1]

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

.....

.....

.....

..... [2]

(c) It is now known that the smell of the seaside is due to the presence of dimethyl sulfide, $(CH_3)_2S$.

(i) Draw a 'dot-and-cross' diagram for dimethyl sulfide, $(CH_3)_2S$.

[2]

(ii) Explain, in terms of bonding and structure, why dimethyl sulfide is a gas at room temperature and pressure.

.....

..... [1]

[Total: 10]

**A4** **(a)** Complete the table.

**Table 4.1**

| electrolyte | state | electrode | half-equation at anode | effect on electrolyte |
|---|---|---|---|---|
| silver nitrate | aqueous | | | no change |
| copper(II) chloride | | graphite | | fully decomposed |

[2]

**(b)** The diagram below shows the electrolysis of concentrated aqueous sodium chloride.

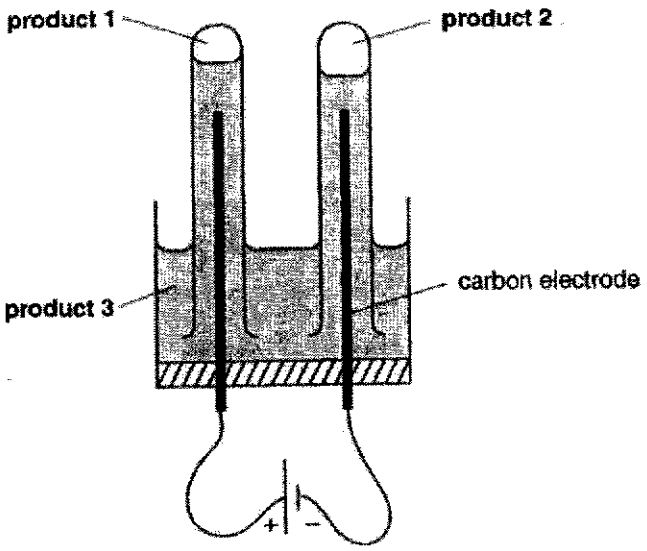



**Fig. 4.2**

**(i)** Write the half equation for the reaction that occurs at the negative electrode.

..... [1]

**(ii)** The volumes of products 1 and 2 should theoretically be the same. Explain why the volume of product 1 is lesser.

..... [1]

**(iii)** What happens to the resulting solution during the electrolysis?

Explain your reasoning.

.....

.....

..... [1]

**(iv)** The same apparatus can be used to electrolyse dilute aqueous sodium chloride. Give **one** similarity and **one** difference between the products of the electrolysis of concentrated and dilute aqueous sodium chloride.

similarity .....

.....

difference .....

.....

.....

..... [2]

[Total: 7]

**A5** Ethanol is the intoxicating ingredient of many alcoholic beverages such as beer.

**(a)** Ethanol is manufactured by the reaction between ethene and steam.

$$C_2H_4\ (g) + H_2O\ (g) \rightarrow C_2H_5OH\ (l)$$

**Table 5**

| bond | C–C | C=C | C–H | O–H | C–O | C=O | O–O | O=O |
|---|---|---|---|---|---|---|---|---|
| bond energy in kJ/mol | 346 | 610 | 414 | 463 | 358 | 804 | 144 | 498 |

**(i)** Using the bond energies provided in Table 5.1, calculate the enthalpy change for this reaction.

enthalpy change ..... [3]

**(ii)** The reaction between ethene and steam is exothermic.

Using ideas about bond breaking and bond forming, explain why the reaction is exothermic.

.....

.....

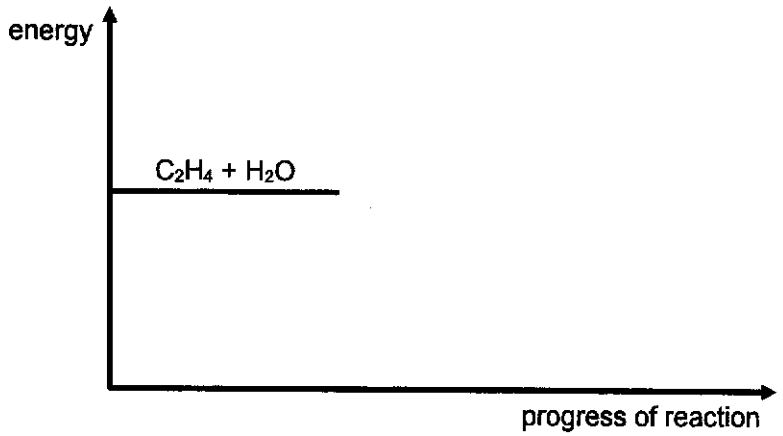
.....

..... [2]

(iii) Complete the energy profile diagram for the reaction between ethene and steam.

Your diagram should show:

- the products of the reaction
- the activation energy for the reaction
- the enthalpy change of reaction, $\Delta H$




[3]

**(b)** Ethanol is also manufactured by the fermentation of glucose.

(i) Write a balanced chemical equation for this fermentation.

..... [1]

(ii) Briefly describe this process.

Include in your answer the conditions needed for fermentation and how the ethanol is purified.

.....

.....

.....

.....

.....

..... [3]

**(c)** Ethanol is oxidised by oxygen in the air to form ethanoic acid.

Ethanol and ethanoic acid can be distinguised by chemical tests.

Describe **two** of these chemical tests and the observations that allow you to make the distinctions.

test 1 .....

observation .....

.....

test 2 .....

observation .....

..... [2]

[Total: 14]

**A6** Poly(propene) and nylon are both used to make strong, waterproof ropes.

Poly(propene) is an addition polymer. Nylon is a condensation polymer.

**(a)** Describe **one** difference between addition polymers and condensation polymers.

.....

.....

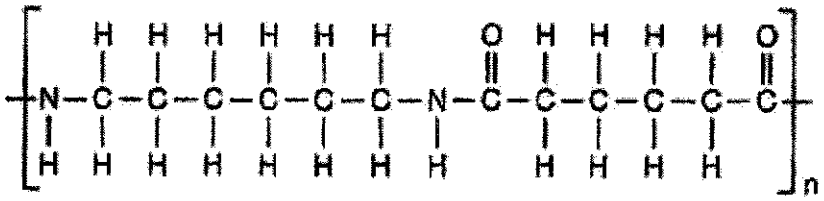
..... [1]

**(b)** Draw the structure of poly(propene), showing two repeat units.

[1]

**(c)** There are several different types of nylon. One type of nylon is nylon-6,6.

This is the repeating unit of nylon-6,6.



**(i)** Draw the structures of the two monomers that react to form nylon-6,6.

[2]

**(ii)** During the manufacturing process, the chain length of the nylon is controlled so that the nylon polymer molecules have an average relative molecular mass in the range 12 000 to 20 000.

What is the range of the average number of repeating units in the nylon-6,6 molecules? Show your working.

range ..... [2]

[Total: 6]

**A7** Read the information about elements and compounds in the Earth.

The Earth's crust is the thin outer layer of the Earth. The pie charts show a comparison of the percentages of elements in the whole Earth and in the Earth's crust.

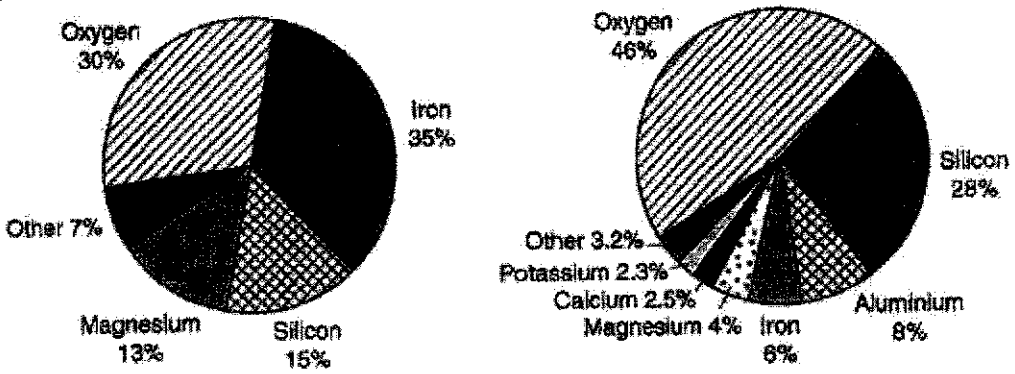



**Fig. 7.1**

In the Earth's crust, silicon and oxygen are the most abundant elements. Rocks such as quartz are made of covalently bonded compounds of silicon and oxygen. Typically, quartz contains 46.7% silicon and 53.3% oxygen by mass.

Some rocks such as feldspars contain ionic silicate compounds. These contain metal ions ionically bonded to silicate ions.

Examples of naturally occurring silicates are shown in the table below.

**Table 7.2**

| name of silicate compound | formula |
|---|---|
| forsterite | $Mg_2SiO_4$ |
| phenacite | $Be_2SiO_4$ |
| anorthite | $CaAl_2Si_2O_8$ |
| microcline | $KAlSi_3O_8$ |

The formulae of the silicate compounds are not simple. Some silicate compounds contain one type of metal ion, others contain more than one. All silicate ions contain silicon and oxygen, but the numbers of the atoms and the charges on the ions vary. For example,

- **phenacite** ($Be_2SiO_4$) contains only $\mathbf{Be^{2+}}$ metal ions and the formula of its silicate ion is $\mathbf{SiO_4^{4-}}$,
- **microcline** ($KAlSi_3O_8$) contains $\mathbf{K^+}$ and $\mathbf{Al^{3+}}$ metal ions and the formula of its silicate ion is $\mathbf{Si_3O_8^{4-}}$.

**(a)** Scientists believe that the centre of the Earth is made from an inner core made mainly of iron.

What evidence from the pie charts supports this idea?

.....

.....

..... [1]

**(b)** **(i)** Use the information to work out the empirical formula and hence the name of the main compound in quartz.

empirical formula .....

name ..... [2]

**(ii)** There are other compounds of oxygen found in the Earth's crust as well as quartz. One such example is potassium oxide.

The table shows some differences between the properties of potassium oxide and the compound in **(b)(i)**.

**Table 7.3**

| compound | melting point / °C | electrical conductivity under room conditions |
|---|---|---|
| potassium oxide | 740 | does not conduct |
| compound in **(b)(i)** | 2230 | does not conduct |

Explain, in terms of bonding and structure, why potassium oxide and the compound in **(b)(i)** have different properties.

.....

.....

.....

.....

.....

.....

.....

..... [4]

**(c)** Give the formulae and charges of the ions present in anorthite.

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

**(d)** Beryllium and silicon can both be extracted from the mineral phenacite.

Show by calculation that 1 kg of phenacite contains a larger mass of silicon than beryllium but a larger number of moles of beryllium atoms than silicon atoms.

[4]

[Total: 12]

**A8** A series of experiments was carried out to investigate the effect of different catalysts on the rate of a reaction.

The table shows the time taken for the reaction to finish when different metal compounds were used as catalysts.

The metal compounds contained Group 1 metals, Group 2 metals or transition metals.

**Table 8**

| experiment | catalyst | temperature at start / °C | time taken for reaction to finish / s |
|---|---|---|---|
| 1 | NaCl | 19 | 45 |
| 2 | $FeCl_2$ | 20 | 22 |
| 3 | $CoCl_2$ | 19 | 26 |
| 4 | $MgCl_2$ | 20 | 46 |
| 5 | $NaNO_3$ | 19 | 45 |
| 6 | $Fe(NO_3)_2$ | 20 | 22 |
| 7 | $Fe(NO_3)_3$ | 19 | 15 |
| 8 | $Co(NO_3)_2$ | 19 | 26 |
| 9 | $Mg(NO_3)_2$ | 19 | 46 |

**(a)** Explain, in terms of collisions and energy, the effect of a catalyst on the rate of a reaction.

.....

.....

..... [2]

**(b)** Group 1 and Group 2 metal compounds are less effective than transition metal compounds as catalysts.

Explain how the information in the table supports this statement.

.....

.....

.....

.....

.....

..... [2]

**(c)** Iron is a transition metal.

Two different iron ions were used in the experiments.

**(i)** Give the formulae of the two ions. ..... and ..... [1]

**(ii)** Which iron ion appears to be the more effective catalyst?

Explain your reasoning.

.....

.....

.....

..... [1]

**(iii)** State **one other** property of transition metals.

..... [1]

**(d)** A student wrote this conclusion from the results in the table.

> The type of anion in the catalyst compound does not affect the rate of reaction.

**(i)** Do you agree with this conclusion?

Use the results to explain your reasoning.

.....

.....

.....

..... [2]

**(ii)** Predict the time taken for the reaction to finish if iron(III) chloride was used as a catalyst.

..... [1]

[Total: 10]

## Section B

Answer **one** question from this section.

**B9** A factory is suspected of releasing non-biodegradable toxic waste such as calcium ions, aluminium ions, zinc ions and nitrate ions into the nearby river.

A scientist tested two samples of the river water by adding excess aqueous sodium hydroxide and aqueous ammonia respectively, followed by warming with aluminium foil. He recorded his observations in Table 9 below.

**Table 9**

| test | on adding a few drops | on adding excess | on warming with aluminium foil |
|---|---|---|---|
| aqueous sodium hydroxide | white precipitate formed | white precipitate, soluble in excess giving a colourless solution | no visible reaction |
| aqueous ammonia | white precipitate formed | white precipitate, some soluble in excess giving a colourless solution, some remained insoluble in excess | gas evolved turns damp litmus paper blue |

Based on this information, the scientist claimed that the factory had indeed been releasing aluminium ions, zinc ions and nitrate ions into the river. However, the factory owner argued that this data showed that the factory was only releasing aluminium ions and zinc ions, but not nitrate ions.

(a) (i) Explain how the data shows that calcium ions are absent, but both aluminium ions and zinc ions are present in the river water.

.....

.....

.....

.....

..... [3]

(ii) The scientist claims that nitrate ions are detected in the river water as the test with aqueous ammonia produced ammonia gas.

Do you agree? Explain your answer.

.....

.....

.....

..... [2]

(b) The river water also contained trace amounts of chloride ions.

Describe how you would carry out a test to show the presence of chloride ions in a solution. Include the observations you would expect.

.....

.....

..... [2]

(c) The salt zinc chloride found in the river water can be prepared in the laboratory.

Describe how a pure sample of zinc chloride crystals can be prepared from insoluble zinc carbonate.

.....

.....

.....

.....

..... [3]

[Total: 10]

**B10** The reactivity series summarises information about the reactions of metals with acids and water, displacement reactions and the extraction of metals from their ores.

**(a)** A student carried out some experiments to place four metals, **W**, **X**, **Y** and **Z** in order of reactivity. The table shows the results.

**Table 10.1**

| | metal **W** | metal **X** | metal **Y** | metal **Z** |
|---|---|---|---|---|
| solution of **W** nitrate | | × | × | × |
| solution of **X** nitrate | ✓ | | ✓ | ✓ |
| solution of **Y** nitrate | ✓ | × | | ✓ |
| solution of **Z** nitrate | ✓ | × | × | |

[key: ✓ = shows a reaction happened; × = shows no reaction happened]

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

..... [1]

**(ii)** Metal **Z** reacts with hydrochloric acid.

What would you see when metal **Z** reacts with hydrochloric acid?

Explain your reasoning.

.....

.....

..... [2]

**(iii)** The student carried out further experiments to place metal **M** in the list.

She used dilute hydrochloric acid and samples of the metals.

She found out that metal **M** is the fourth most reactive metal.

Describe the experiments that the student carried out.

Your answer should include

- the experiments that she carried out using dilute hydrochloric acid and samples of the metals,
- the measurements that she made,
- how the results showed that metal **M** is the fourth most reactive metal.

.....

.....

.....

.....

.....

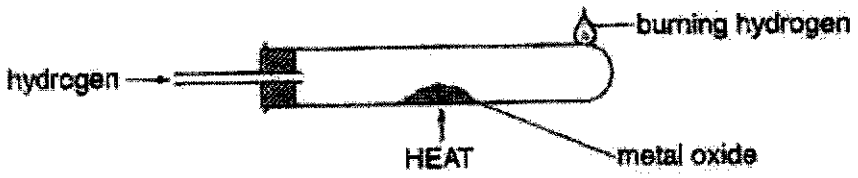
.....

.....

.....

..... [3]

**(b)** The student also carried out some experiments to investigate the reduction of three metal oxides by hydrogen.



The table shows the appearance of each metal oxide when cold.

**Table 10.2**

| experiment | metal oxide | colour when cold |
|---|---|---|
| 1 | calcium oxide | white |
| 2 | copper oxide | red |
| 3 | lead oxide | yellow |

**(i)** What would you expect to see happen in each experiment?

Explain your answer.

.....

.....

..... [2]

**(ii)** In which tube would you expect to see the fastest reaction?

Explain your answer.

.....

.....

..... [2]

[Total: 10]

[Insert Periodic Table]

# MARK SCHEME

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

# MARK SCHEME

**Section A [70 m]**

**A1**

(a) calcium hydroxide (c) sulfur dioxide and nitrogen dioxide [2]
(b) magnesium (d) nitrogen and hydrogen [2]

**A2**

(a) (i) ethanoic acid, $CH_3COOH$; propanol, $C_3H_7OH$ [2]
(ii) At higher temperatures, the reacting particles move faster leading to [1]
a higher frequency of effective collisions between the particles, [1]
resulting in a higher rate of diffusion.
(b) (i) The esters have the same general formula, $HCO_2C_nH_{2n+1}$. / [1]
The esters have the same functional group, $HCO_2$.
(ii) Methyl methanoate [1]
It has the lowest relative molecular mass of 60. [1]

**A3**

(a) (i)

| symbol | number of protons | number of neutrons | number of electrons |
|---|---|---|---|
| $^{79}_{35}Br$ | 35 | 44 | 35 |
| $^{81}_{35}Br^-$ | 35 | 46 | 36 |

[1]
[1]

(ii) *Isotopes* have the same number of protons (i.e. 35 protons) but [1]
different number of neutrons (i.e. 44 and 146 neutrons).
(iii) $Cl_2$ (g) + 2$Br^-$ (aq) → 2$Cl^-$ (aq) + $Br_2$ (*l*) [1]
(iv) Astatine, being less reactive than bromine, is unable to displace [1]
bromine from its salt.
(b) (i) The colourless solution turns dark-brown. [1]
(ii) The iodine in potassium iodide undergoes oxidation, as the [1]
oxidation state of iodine increases from -1 in $I^-$ to 0 in $I_2$.
The oxygen in ozone undergoes reduction, as the oxidation state of [1]
oxygen decreases from 0 in $O_3$ to -2 in $H_2O$.
(c) (i) 'Dot-and-cross' diagram [covalent; $H_3C - S - CH_3$] [2]
(ii) Dimethyl sulfuide is a simple covalent molecule. [1]
A small amount of heat energy is required to overcome the weak
intermolecular forces of attraction between **molecules**.

**A4**

(a) silver; Ag (s) → $Ag^+$ (aq) + $e^-$ [1]
molten; 2$Cl^-$ (*l*) → $Cl_2$ (g) + 2$e^-$ [1]
(b) (i) 2$H^+$ (aq) + 2$e^-$ → $H_2$ (g) [1]
(ii) As chlorine is slightly soluble in water, the volume collected is [1]
lesser.
(iii) The resulting solution becomes increasingly alkaline. [1]
With the removal of $H^+$ and $Cl^-$ ions, the remaining $Na^+$ and $OH^-$
combine to form the strong alkali, NaOH.
(iv) similarity
At the cathode, $H^+$ ions are discharged to form hydrogen gas. [1]
difference
At the anode, $OH^-$ ions are discharged to form oxygen gas for dilute [1]
aqueous sodium chloride, while $Cl^-$ ions are discharged to form
chlorine gas for concentrated aqueous sodium chloride.

**A5**

**(a) (i)** energy absorbed for bond-breaking = 610 + 4(414) + 2(463) = 3192 kJ/mol [1]

energy released for bond-forming = 346 + 5(414) + 358 + 463 = 3237 kJ/mol [1]

enthalpy change of reaction = 3192 + (-3237) = <u>-45 kJ/mol</u> [1]

**(ii)** <u>More</u> energy is <u>released</u> in bond forming (i.e. C-C, C-H, C-O and O-H) than <u>absorbed</u> in bond breaking (i.e. C=C, C-H and O-H). [2]

**(iii)** on diagram:

- the products of the reaction [1]
- the activation energy for the reaction [1]
- the enthalpy change of reaction, $\Delta H$ [1]

**(b) (i)** $\underline{C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2}$ [1]

**(ii)** The fermentation of glucose can be carried out using <u>yeast</u> as catalyst. The mixture is kept at a temperature of about <u>37°C</u>, producing a dilute solution of ethanol, with concentration <u>12-14%</u>. The process is carried out under <u>anaerobic</u> conditions. [2]

Ethanol is purified using <u>fractional distillation</u>. [1]

**(c)** test 1 : To 5 $cm^3$ of sample, add 1 g of <u>solid sodium carbonate</u>. [1]

observation : With ethanol, there is <u>no visible reaction</u>.
With ethanoic acid, <u>effervescence</u> is observed.

test 2 : To 5 $cm^3$ of sample, add an equal volume of <u>acidified potasisum manganate(VII)</u>. [1]

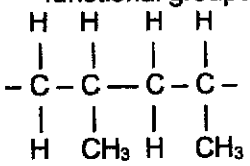
observation : With ethanol, the <u>purple</u> solution turns <u>colourless</u>.
With ethanoic acid, <u>no visible reaction</u>.

**A6**

**(a)** Choose any <u>one</u>: [1]

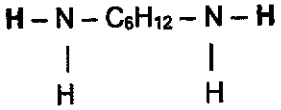
- The addition polymer contains the <u>C-C chain</u>, while the condensation polymer contains the <u>amide</u> or <u>ester</u> linkages.
- The formation of addition polymers <u>does not involve any loss of small molecules</u> (i.e. 1 product formed). While the formation of condensation polymers <u>involves the loss of small molecules</u> like water (i.e. 2 products formed).
- The formation of addition polymers involves the <u>C=C</u> functional group, while the formation of condensation polymers involves monomers with functional groups like <u>$-NH_2$, $-COOH$ and $-OH$</u>.

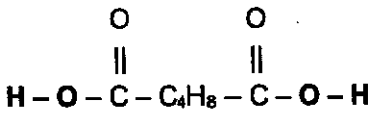
**(b)**



[1]

**(c) (i)**





[2]

**(ii)** $M_r$ of $C_{12}H_{22}N_2O_2$ = 226 [1]

range = <u>54 to 88</u> [1]

**A7** **(a)** The pie charts show that there is 35% of iron in the whole Earth, while there is only 6% in the Earth's crust. This implies that 29% of the iron is in the inner core of the Earth. [1]

**(b)** **(i)**

| | Si | O |
|---|---|---|
| percentage | 46.7 | 53.3 |
| $A_r$ | 28 | 16 |
| no. of moles | 1.6679 | 3.3333 |
| ÷ 1.6679 | 1 | 2 |

empirical formula = $SiO_2$; name = silicon dioxide [2]

**(ii)** Potassium oxide is an ionic compound. [1]

A large amount of heat energy is required to overcome the strong electrostatic forces of attraction between oppositely-charged ions. [1]

Silicon dioxide is a giant covalent molecule.

An even larger amount of heat energy is required to overcome the stronger covalent bonds between atoms.

For potassium oxide, the ions are held rigidly in fixed positions in the solid state. The absence of mobile charged ions prevents the electric current from being carried. [1]

For silicon dioxide, all valence electrons are used for bonding. The absence of mobile charged electrons prevents the electric current from being carried. [1]

**(c)** $Ca^{2+}$, $Al^{3+}$ and $Si_2O_8^{8-}$ [1]

**(d)** $M_r$ of phenacite = 110

mass of silicon in phenacite = $\frac{28}{110} \times 1000\ g = 255\ g$ (to 3 s.f.) [1]

mass of beryllium in phenacite = $\frac{2(9)}{110} \times 1000\ g = 164\ g$ (to 3 s.f.) [1]

From the above calculations, 1 kg of phenacite contains a larger mass of silicon than beryllium.

no. of mol. of silicon = $\frac{254.545g}{28} = 9.09\ mol$ (to 3 s.f.) [1]

no. of mol. of beryllium = $\frac{163.636g}{9} = 18.2\ mol$ (to 3 s.f.) [1]

From the above calculations, 1 kg of phenacite contains a larger number of moles of beryllium atoms than silicon atoms.

**A8** **(a)** A catalyst provides an alternative pathway with a lower activation energy [1] for the reaction to proceed, leading to a higher frequency of effective collisions between the particles, resulting in a higher rate of reaction. [1]

**(b)** Comparing experiments 5, 7, 8 and 9, with the same starting temperature of 19°C, Group 1 and 2 metal compounds are less effective as the time taken for reaction to finish is longer (i.e. $NaNO_3$ takes 45s, while [1] $Mg(NO_3)_2$ takes 46 s), as compared to the transition metal compounds which take a shorter time (i.e. $Fe(NO_3)_3$ takes 15s, and $Co(NO_3)_2$ takes 26s. [1]

**(c)** **(i)** $Fe^{2+}$ and $Fe^{3+}$ [1]

| | | |
|---|---|---|
| | (ii) Iron(III) ion is the more effective catalyst.<br>Comparing experiments 6 and 7, iron(III) ion took a shorter time (i.e. 15s in experiment 7) to complete the reaction, as compared to that of iron(II) ion (i.e. 22s in experiment 6), despite the slight change in temperature. | [1] |
| | (iii) Transition metals form coloured compounds when hydrated. | [1] |
| | (d) (i) Yes.<br>Comparing experiments 1 and 5, both NaCl and $NaNO_3$ took 45s to complete the reaction, regardless of the anion.<br>Also, comparing experiments 2 and 6, both $FeCl_2$ and $Fe(NO_3)_2$ took 22s to complete the reaction, regardless of the anion. | [2] |
| | (ii) 15s | [1] |

**Section B [10 m]**

| | | | | |
|---|---|---|---|---|
| **B9** | **(a)** | **(i)** | From the test with aqueous NaOH, the white precipitate formed is soluble in excess, implying that both $A\ell^{3+}$ ions and $Zn^{2+}$ ions are present. If $Ca^{2+}$ ion is present, then some white precipitate formed is insoluble in excess. | [1]<br>[1] |
| | | | From the test with aqueous $NH_4OH$, some white precipitate formed is soluble in excess, confirming that $Zn^{2+}$ ions are present, while some white precipitate formed is insoluble in excess, confirming that $A\ell^{3+}$ ions are present. | [1] |
| | | **(ii)** | No, the ammonia gas produced could be due to the presence of aqueous ammonia. | [1] |
| | | | To test for nitrate ions, the scientist should use warm aqueous sodium hydroxide and aluminium foil. | [1] |
| | **(b)** | test | : To a 2 $cm^3$ sample of river water, add an equal volume of dilute acid, followed by aqueous silver nitrate. | [1] |
| | | result | : white precipitate formed | [1] |
| | **(c)** | | 1. Add excess zinc carbonate [base] powder to warm dilute hydrochloric acid [acid]. | [1] |
| | | | 2. Filter the mixture to remove the excess zinc chloride. | |
| | | | 3. Heat the filtrate till it is saturated. | [1] |
| | | | 4. Allow the solution to cool and crystals of zinc chloride will form. Filter off the crystals. | |
| | | | 5. Wash the crystals with distilled water. | [1] |
| | | | Dry the pieces of crystals between two pieces of filter paper. | |
| **B10** | **(a)** | **(i)** | **W > Z > Y > X** | [1] |
| | | **(II)** | Effervescence is observed. | [1] |
| | | | Metal **Z**, being a reactive metal (i.e. above H in the reactivity series), reacts with acid to displace hydrogen gas. | [1] |
| | | **(iii)** | Approach:<br>The student measured and compared the volume of hydrogen gas collected for a metal of fixed mass (i.e. 0.5 g each of metals **W**, **X**, **Y**, **Z** and **M**) to react completely with dilute hydrochloric acid of a fixed concentration (i.e. 1 mol/$dm^3$) and volume (30 $cm^3$) over a 2-minute duration. | [1] |

| | | | | |
|---|---|---|---|---|
| | | | Procedure:<br>1. Using a 50 $cm^3$ measuring cylinder, measure 30 $cm^3$ of HC*l* and place it in a 250 $cm^3$ conical flask.<br>2. Transfer the dilute hydrochloric acid into the conical flask, connect a gas syringe<br>3. Using an electronic mass balance, measure 0.5 g of metal **W** and add it to the conical flask.<br>Stopper the conical flask and connect a gas syringe to the conical flask using a delivery tube. **Start the stopwatch immediately.**<br>4. Stop the stopwatch when it reaches 2 minutes.<br>Record the volume of gas produced in a table of suitable format. | [1] |
| | | | Conclusion:<br>Metal **W** will have the highest volume of hydrogen gas collected, followed by metals **Z**, **Y**, **M** (i.e. 4th most reactive) and **X**. | [1] |
| | **(b)** | **(i)** | There is no visible reaction for experiments 1 and 3.<br>Calcium and lead, being more reactive than hydrogen, cannot be displaced from their oxide by hydrogen.<br>In experiment 2, the red copper oxide turns red-brown.<br>Copper, being less reactive than hydrogen, can be displaced from its oxide by hydrogen. | [1]<br><br>[1] |
| | | **(ii)** | The tube containing copper oxide.<br>Copper, being the least reactive metal, forms the least stable metal oxide, hence the oxide is more readily reduced by hydrogen. | [1] |