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CANDIDATE NAME

CENTRE NUMBER

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9904169354

CHEMISTRY **0620/42**

Paper 4 Theory (Extended) **May/June 2021**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **16** pages. Any blank pages are indicated.

[Turn over

1 The symbols of the elements of Period 3 of the Periodic Table are shown.

Na	Mg	Al	Si	P	S	Cl	Ar

Answer the following questions about these elements.
Each element may be used once, more than once or not at all.

Write the symbol of an element which:

(a) is malleable (Metals are Malleable

Na, Mg or Al ..... [1]

(b) has only two electrons in its outermost shell Group 2 elements.

Mg ..... [1]

(c) forms an oxide which leads to acid rain

S ..... [1]

(d) forms an ion with a 2– charge (Group 6) Needs to gain two more electrons.

S ..... [1]

(e) is extracted from an ore called bauxite (Used in electrolysis of Aluminium oxide)

Al ..... [1]

(f) does **not** form an oxide (Argon is unreactive hence do not form oxides)

Ar ..... [1]

(g) forms an oxide with a macromolecular structure

Si ..... [1]

(h) forms an amphoteric oxide (Has properties of both acidic and basic oxides).

Al ..... [1]

(i) exists as diatomic molecules (Molecules made up of two atoms.

Cl ..... [1]

(j) forms a binary compound with hydrogen that is a strong acid.

Cl ..... [1]

[Total: 10]

2 Silver has an atomic number of 47.

(a) Naturally occurring atoms of silver are ^{107}Ag and ^{109}Ag.

(i) State the name given to atoms of the same element with different nucleon numbers.

Isotopes ..... [1]

(ii) Complete the table to show the number of protons, neutrons and electrons in each atom and ion of silver shown.

Neutrons = Mass Number − Atomic number

	$^{107}_{47}Ag$	$^{109}_{47}Ag^{+}$
protons	47	47
neutrons	60	62
electrons	47	46

[3]

(iii) Complete this definition of relative atomic mass.

Relative atomic mass is the average mass of naturally occurring atoms of an element on a scale where the carbon-12 (^{12}C) atom has a mass of exactly 12 units.

[3]

(iv) A sample of silver has a relative atomic mass of 108.0.

^{107}Ag 0.5 ^{108}Ag 0.5

Deduce the percentage of ^{107}Ag present in this sample of silver.

0.5 × 100% = 50% ..... [1]

(b) Silver nitrate is a salt of silver made by reacting silver oxide with an acid.

Write the formula of the acid which reacts with silver oxide to form silver nitrate.

HNO_3 ..... [1]

$AgNO_3$ + Ag_2O + HNO_3

Br^- → Cream Precipitate.

(c) Aqueous silver nitrate is a colourless solution containing $Ag^+(aq)$ ions.

(i) Describe what is seen when aqueous silver nitrate is added to aqueous sodium iodide, NaI(aq).

A Yellow Precipitate. [1]

(ii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous sodium iodide.
Include state symbols.

$AgNO_3 + NaI \longrightarrow AgI + NaNO_3(aq)$

$Ag^+(aq) + NO_3^-(aq) + Na^+(aq) + I^- \longrightarrow AgI + Na^+ + NO_3^-$

$Ag^+ + I^- \longrightarrow AgI(s)$. [3]

(d) In the positive test for aqueous nitrate ions, aqueous sodium hydroxide and one other substance are warmed with the nitrate ions. NaOH

Name this other substance and the gas formed.

name of substance Aluminium

name of gas Ammonia

[2]

(e) When silver nitrate is exposed to sunlight, silver is formed.

Name the type of reaction which needs light to make it happen.

Photochemical [1]

(f) Members of one homologous series only react with chlorine in the presence of sunlight (Substitution) (Alkanes)

(i) Name a member of this homologous series.

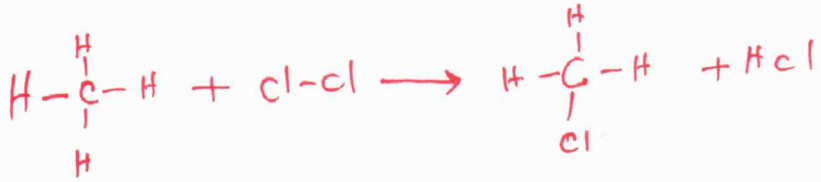
Methane
Ethane. [1]

(ii) Name **two** products that form when the compound in **(i)** reacts with chlorine.

1 Hydrogen chloride

2 Chloromethane. [2]

[Total: 19]



3 Sodium hydrogencarbonate is found in baking powder.

When sodium hydrogencarbonate is heated it forms three products.

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

(a) Name the type of reaction that takes place when sodium hydrogencarbonate reacts in this way.

Thermal decomposition.

..... [1]

(b) Calculate the volume of carbon dioxide formed at room temperature and pressure when 12.6 g of $NaHCO_3$ is heated using the following steps:

- determine the mass of one mole of $NaHCO_3$

$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$

2 : 1 : 1 : 1

Mass = $NaHCO_3$

$23 + 1 + 12 + (16 \times 3)$

$= 23 + 1 + 12 + 48$

$= 84$

84 ..... g

- calculate the number of moles of $NaHCO_3$ used

No. of Moles = $\frac{12.6\,g}{84} = 0.15$ Moles

0.15 ..... moles

- determine the number of moles of carbon dioxide formed

No. of Moles of $CO_2 = \frac{0.15}{2}$

$= 0.075$

0.075 ..... moles

- calculate the volume of carbon dioxide formed at room temperature and pressure.

Volume = No. of Moles $\times$ 24 dm^3

$= 0.075 \times 24$

$= 1.8\ dm^3$

1.8 ..... dm^3

[4]

(c) Limewater is aqueous calcium hydroxide. Carbon dioxide turns limewater milky because a white precipitate forms.

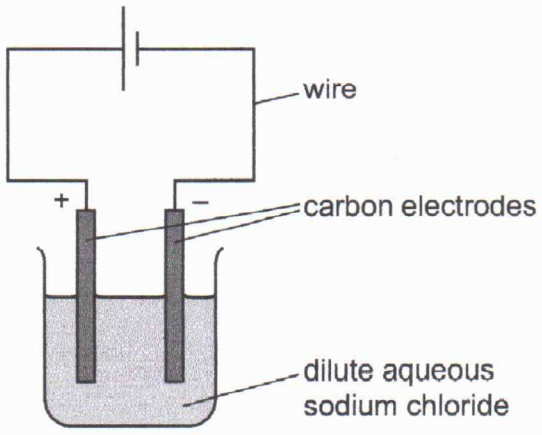
Write the formula of:

- calcium hydroxide ..... $Ca(OH)_2$ .....
- the white precipitate that forms when limewater turns milky. ..... $CaCO_3$ .....

[2]

[Total: 7]

4 A student carries out an electrolysis experiment using the apparatus shown.



Na^+ Cl^- since it is aqueous it contains water. (H^+ and OH^-)

$2H + 2e^- \rightarrow H_2(g)$

The student uses dilute aqueous sodium chloride.

(a) State the name given to any solution which undergoes electrolysis.

electrolyte. [1]

(b) Hydroxide ions are discharged at the anode.

(i) Complete the ionic half-equation for this reaction.

4 $OH^-(aq) \rightarrow 2H_2O + O_2(g) + 4e^-$ [2]

(ii) Explain how the ionic half-equation shows the hydroxide ions are being oxidised.

It releases electrons (It loses electrons) [1]

(c) Describe what the student observes at the cathode.

Bubbles are observed due to the production of gas [1]

(d) Write the ionic half-equation for the reaction at the cathode.

$2H^+ + 2e^- \rightarrow H_2$ [2]

(e) The student repeats the experiment using concentrated aqueous sodium chloride.

(i) Describe what the student observes at:

- the cathode There would be fizzing.
- the anode. Green gas is produced.

[2]

(ii) The student added litmus to the solution after the electrolysis of concentrated aqueous sodium chloride.

State the colour seen in the solution. Give a reason for your answer.

colour of solution It turns red litmus to blue.

reason The sodium hydroxide solution formed is alkaline.

[2]

(f) Carbon electrodes are used because they are inert.

State another element that can be used instead of carbon.

Platinum. [1]

[Total: 12]

5 This question is about compounds of nitrogen.

(a) Nitrogen reacts with lithium to form lithium nitride, Li_3N.

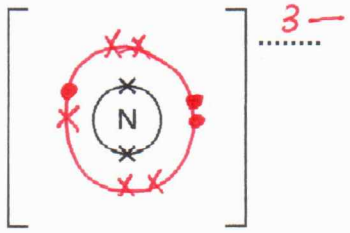
(i) Write the chemical equation for the reaction between lithium and nitrogen.

$6Li_{(s)} + N_{2(g)} \longrightarrow 2Li_3N$ [2]

(ii) Lithium nitride is ionically bonded.

Complete the diagram to show the electronic structure of the nitride ion.
Show the charge on the nitride ion.

N = 2.5
N^{3-} 2.8
(It gains three electrons)



[2]

(b) Nitrogen reacts with fluorine to form nitrogen trifluoride, NF_3.

(i) The chemical equation can be represented as shown.

$$N{\equiv}N + 3\,F{-}F \rightarrow 2\,F{-}\underset{\displaystyle F}{\overset{\displaystyle |}{N}}{-}F$$

Some bond energies are shown in the table.

bond	bond energy in kJ/mol
N≡N	945
F–F	160
N–F	300

Breaking the bonds (heat is absorbed) Endothermic reaction

Making bonds heat is given out (Exothermic)

Calculate the energy change for the reaction between nitrogen and fluorine, using the following steps:

- energy taken in to break bonds

N≡N → 945 kJ/mol

3 (F-F) → 160 × 3 = 480 kJ/mol

1425 kJ/mol

1425 ..... kJ

- energy released when bonds are formed

6 (N-F) = 300 × 6

= 1800 kJ

1800 ..... kJ

- energy change during the reaction.

Energy change = +1425 − 1800

= −375 kJ/mol

−375 ..... kJ/mol [3]

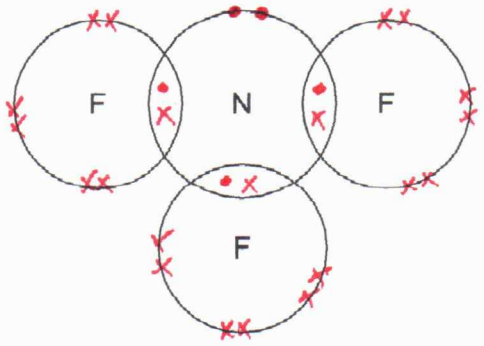
(ii) Use your answer to **(i)** to deduce whether this reaction is endothermic or exothermic. Explain your answer.

Exothermic, More energy is released when forming the bond, compared to energy used in breaking the bonds. [1]

(iii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of NF_3.

Use dots for nitrogen electrons and crosses for fluorine electrons.

Show outer electrons only.



F 2.7
F^- 2.8

N = 2.5
N^{3-} = 2.8

[3]

(c) Lithium nitride melts at 813 °C. Nitrogen trifluoride melts at –206 °C.

Explain in terms of attractive forces why lithium nitride has a much higher melting point than nitrogen trifluoride.

In your answer refer to the types of attractive forces between particles and their relative strengths.

Lithium nitride has strong ionic bonding which requires high amount of heat energy to break their bonds, However in nitrogen trifluoride has very weak covalent between Molecules and requires less energy to break the bonds. [3]

(d) Ammonium nitrate, NH_4NO_3, is a compound of nitrogen.

(i) Calculate the percentage by mass of nitrogen in ammonium nitrate.

RFM: NH_4NO_3

$14+(4\times1)+14+(16\times3)$

$= 14+4+14+48$

$= 80$

% Mass of Nitrogen = $14\times2=28$

$\frac{28}{80}\times100\% = 35\%$

percentage by mass of nitrogen = 35 % [2]

(ii) State a use of ammonium nitrate in agriculture.

It is Used as a fertiliser. [1]

(iii) State the name of a compound that will displace ammonia from ammonium nitrate.

Calcium hydroxide. [1]

(e) Ammonia is a base which forms a weakly alkaline solution when dissolved in water.

(i) Define the term *base*.

It is a Proton acceptor. ..... [1]

(ii) Suggest the pH of aqueous ammonia.

PH 9. ..... [1]

[Total: 20]

Since it is Weakly alkaline the pH ranges $7 < x \leq 11$.

6 Molecules **A** and **B** can form condensation polymers.

A

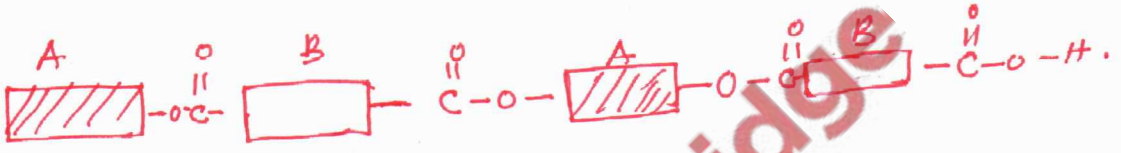
B

(a) Each molecule has two identical functional groups.

(i) Name the functional group in **B**.

Carboxylic acid [1]

(ii) Draw the part of the structure of the synthetic polymer that would form when two molecules of **A** and two molecules of **B** combine. Show all of the bonds in the linkages.



[3]

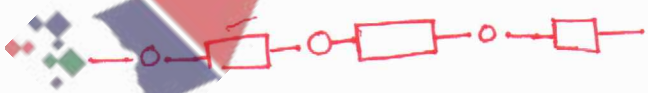
(iii) Name the other product formed when molecules of **A** and **B** undergo polymerisation.

Water. [1]

(b) Molecule **A** is a simple sugar unit which can be made by hydrolysis of complex carbohydrates.

(i) Draw part of the complex carbohydrate that could be hydrolysed to make molecules of **A**.

Include **one** linkage and show all of the bonds in the linkage.



[1]

(ii) State **two** sets of conditions which could be used to hydrolyse the complex carbohydrate to form **A**.

1 Acid and heat.

2 Enzymes. [2]

(iii) Name the technique used to identify the individual sugar units made by the hydrolysis of a complex carbohydrate.

Chromatography. [1]

(c) Ethanol can be made from the simple sugar glucose, $C_6H_{12}O_6$.

(i) State the name of this process.

Fermentation ..... [1]

(ii) Complete the chemical equation for this reaction.

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ [2]

[Total: 12]