

Candidate Name

Candidate Number

Centre Name

Centre Number

Paper 1: Chemistry

For Examination December 2023

(2 hours)

It is necessary to respond on the answer sheets provided alongside this question paper. Additionally, you must have a soft pencil (preferably of type B or HB), a clean eraser and a dark blue or black pen.

INSTRUCTIONS:

- You must write your name, candidate number, centre name and centre number on the answer sheets in the designated spaces.
- Attempt all the questions from using a dark blue or black pen.
- It is important to follow the instructions provided on the answer sheets.
- Do not use correction fluid.
- Avoid writing on any bar codes.

INFORMATION:

The number of marks assigned for every question or its parts is indicated within brackets []

The Periodic Table of Elements

Group																								
1	2													13	14	15	16	17	18					
<div>Key</div> <div>atomic number</div> <div>atomic symbol</div> <div>name</div> <div>relative atomic mass</div>												<div>¹H</div> <div>hydrogen</div> <div>1.0</div>												<div>²He</div> <div>helium</div> <div>4.0</div>
												<div>3</div> <div>Li</div> <div>lithium</div> <div>6.9</div>	<div>4</div> <div>Be</div> <div>beryllium</div> <div>9.0</div>											<div>5</div> <div>B</div> <div>boron</div> <div>10.8</div>
<div>11</div> <div>Na</div> <div>sodium</div> <div>23.0</div>	<div>12</div> <div>Mg</div> <div>magnesium</div> <div>24.3</div>	<div>3</div>	<div>4</div>	<div>5</div>	<div>6</div>	<div>7</div>	<div>8</div>	<div>9</div>	<div>10</div>	<div>11</div>	<div>12</div>	<div>Al</div> <div>aluminium</div> <div>27.0</div>	<div>Si</div> <div>silicon</div> <div>28.1</div>	<div>P</div> <div>phosphorus</div> <div>31.0</div>	<div>S</div> <div>sulfur</div> <div>32.1</div>	<div>Cl</div> <div>chlorine</div> <div>35.5</div>	<div>Ar</div> <div>argon</div> <div>39.9</div>							
<div>19</div> <div>K</div> <div>potassium</div> <div>39.1</div>	<div>20</div> <div>Ca</div> <div>calcium</div> <div>40.1</div>	<div>21</div> <div>Sc</div> <div>scandium</div> <div>45.0</div>	<div>22</div> <div>Ti</div> <div>titanium</div> <div>47.9</div>	<div>23</div> <div>V</div> <div>vanadium</div> <div>50.9</div>	<div>24</div> <div>Cr</div> <div>chromium</div> <div>52.0</div>	<div>25</div> <div>Mn</div> <div>manganese</div> <div>54.9</div>	<div>26</div> <div>Fe</div> <div>iron</div> <div>55.8</div>	<div>27</div> <div>Co</div> <div>cobalt</div> <div>58.9</div>	<div>28</div> <div>Ni</div> <div>nickel</div> <div>58.7</div>	<div>29</div> <div>Cu</div> <div>copper</div> <div>63.5</div>	<div>30</div> <div>Zn</div> <div>zinc</div> <div>65.4</div>	<div>31</div> <div>Ga</div> <div>gallium</div> <div>69.7</div>	<div>32</div> <div>Ge</div> <div>germanium</div> <div>72.6</div>	<div>33</div> <div>As</div> <div>arsenic</div> <div>74.9</div>	<div>34</div> <div>Se</div> <div>selenium</div> <div>79.0</div>	<div>35</div> <div>Br</div> <div>bromine</div> <div>79.9</div>	<div>36</div> <div>Kr</div> <div>krypton</div> <div>83.8</div>							
<div>37</div> <div>Rb</div> <div>rubidium</div> <div>85.5</div>	<div>38</div> <div>Sr</div> <div>strontium</div> <div>87.6</div>	<div>39</div> <div>Y</div> <div>yttrium</div> <div>88.9</div>	<div>40</div> <div>Zr</div> <div>zirconium</div> <div>91.2</div>	<div>41</div> <div>Nb</div> <div>niobium</div> <div>92.9</div>	<div>42</div> <div>Mo</div> <div>molybdenum</div> <div>95.9</div>	<div>43</div> <div>Tc</div> <div>technetium</div> <div>–</div>	<div>44</div> <div>Ru</div> <div>ruthenium</div> <div>101.1</div>	<div>45</div> <div>Rh</div> <div>rhodium</div> <div>102.9</div>	<div>46</div> <div>Pd</div> <div>palladium</div> <div>106.4</div>	<div>47</div> <div>Ag</div> <div>silver</div> <div>107.9</div>	<div>48</div> <div>Cd</div> <div>cadmium</div> <div>112.4</div>	<div>49</div> <div>In</div> <div>indium</div> <div>114.8</div>	<div>50</div> <div>Sn</div> <div>tin</div> <div>118.7</div>	<div>51</div> <div>Sb</div> <div>antimony</div> <div>121.8</div>	<div>52</div> <div>Te</div> <div>tellurium</div> <div>127.6</div>	<div>53</div> <div>I</div> <div>iodine</div> <div>126.9</div>	<div>54</div> <div>Xe</div> <div>xenon</div> <div>131.3</div>							
<div>55</div> <div>Cs</div> <div>caesium</div> <div>132.9</div>	<div>56</div> <div>Ba</div> <div>barium</div> <div>137.3</div>	<div>57–71</div> <div>lanthanoids</div>	<div>72</div> <div>Hf</div> <div>hafnium</div> <div>178.5</div>	<div>73</div> <div>Ta</div> <div>tantalum</div> <div>180.9</div>	<div>74</div> <div>W</div> <div>tungsten</div> <div>183.8</div>	<div>75</div> <div>Re</div> <div>rhenium</div> <div>186.2</div>	<div>76</div> <div>Os</div> <div>osmium</div> <div>190.2</div>	<div>77</div> <div>Ir</div> <div>iridium</div> <div>192.2</div>	<div>78</div> <div>Pt</div> <div>platinum</div> <div>195.1</div>	<div>79</div> <div>Au</div> <div>gold</div> <div>197.0</div>	<div>80</div> <div>Hg</div> <div>mercury</div> <div>200.6</div>	<div>81</div> <div>Tl</div> <div>thallium</div> <div>204.4</div>	<div>82</div> <div>Pb</div> <div>lead</div> <div>207.2</div>	<div>83</div> <div>Bi</div> <div>bismuth</div> <div>209.0</div>	<div>84</div> <div>Po</div> <div>polonium</div> <div>–</div>	<div>85</div> <div>At</div> <div>astatine</div> <div>–</div>	<div>86</div> <div>Rn</div> <div>radon</div> <div>–</div>							
<div>87</div> <div>Fr</div> <div>francium</div> <div>–</div>	<div>88</div> <div>Ra</div> <div>radium</div> <div>–</div>	<div>89–103</div> <div>actinoids</div>	<div>104</div> <div>Rf</div> <div>rutherfordium</div> <div>–</div>	<div>105</div> <div>Db</div> <div>dubnium</div> <div>–</div>	<div>106</div> <div>Sg</div> <div>seaborgium</div> <div>–</div>	<div>107</div> <div>Bh</div> <div>bohrium</div> <div>–</div>	<div>108</div> <div>Hs</div> <div>hassium</div> <div>–</div>	<div>109</div> <div>Mt</div> <div>meitnerium</div> <div>–</div>	<div>110</div> <div>Ds</div> <div>darmstadtium</div> <div>–</div>	<div>111</div> <div>Rg</div> <div>roentgenium</div> <div>–</div>	<div>112</div> <div>Cn</div> <div>copernicium</div> <div>–</div>	<div>113</div> <div>Nh</div> <div>nihonium</div> <div>–</div>	<div>114</div> <div>Fl</div> <div>flerovium</div> <div>–</div>	<div>115</div> <div>Mc</div> <div>moscovium</div> <div>–</div>	<div>116</div> <div>Lv</div> <div>livermorium</div> <div>–</div>	<div>117</div> <div>Ts</div> <div>tennessine</div> <div>–</div>	<div>118</div> <div>Og</div> <div>oganeson</div> <div>–</div>							
lanthanoids		<div>57</div> <div>La</div> <div>lanthanum</div> <div>138.9</div>	<div>58</div> <div>Ce</div> <div>cerium</div> <div>140.1</div>	<div>59</div> <div>Pr</div> <div>praseodymium</div> <div>140.9</div>	<div>60</div> <div>Nd</div> <div>neodymium</div> <div>144.4</div>	<div>61</div> <div>Pm</div> <div>promethium</div> <div>–</div>	<div>62</div> <div>Sm</div> <div>samarium</div> <div>150.4</div>	<div>63</div> <div>Eu</div> <div>europium</div> <div>152.0</div>	<div>64</div> <div>Gd</div> <div>gadolinium</div> <div>157.3</div>	<div>65</div> <div>Tb</div> <div>terbium</div> <div>158.9</div>	<div>66</div> <div>Dy</div> <div>dysprosium</div> <div>162.5</div>	<div>67</div> <div>Ho</div> <div>holmium</div> <div>164.9</div>	<div>68</div> <div>Er</div> <div>erbium</div> <div>167.3</div>	<div>69</div> <div>Tm</div> <div>thulium</div> <div>168.9</div>	<div>70</div> <div>Yb</div> <div>ytterbium</div> <div>173.1</div>	<div>71</div> <div>Lu</div> <div>lutetium</div> <div>175.0</div>								
actinoids		<div>89</div> <div>Ac</div> <div>actinium</div> <div>–</div>	<div>90</div> <div>Th</div> <div>thorium</div> <div>232.0</div>	<div>91</div> <div>Pa</div> <div>protactinium</div> <div>231.0</div>	<div>92</div> <div>U</div> <div>uranium</div> <div>238.0</div>	<div>93</div> <div>Np</div> <div>neptunium</div> <div>–</div>	<div>94</div> <div>Pu</div> <div>plutonium</div> <div>–</div>	<div>95</div> <div>Am</div> <div>americium</div> <div>–</div>	<div>96</div> <div>Cm</div> <div>curium</div> <div>–</div>	<div>97</div> <div>Bk</div> <div>berkelium</div> <div>–</div>	<div>98</div> <div>Cf</div> <div>californium</div> <div>–</div>	<div>99</div> <div>Es</div> <div>einsteinium</div> <div>–</div>	<div>100</div> <div>Fm</div> <div>fermium</div> <div>–</div>	<div>101</div> <div>Md</div> <div>mendelevium</div> <div>–</div>	<div>102</div> <div>No</div> <div>nobelium</div> <div>–</div>	<div>103</div> <div>Lr</div> <div>lawrencium</div> <div>–</div>								

Instructions: Answer **all** the questions in the space provided.

Question 1

Gallium is a metal in Group 13 of the Periodic Table.

- (a) There are two stable isotopes of gallium, ^{69}Ga and ^{71}Ga .

State, with reference to subatomic particles, how the isotopes ^{69}Ga and ^{71}Ga differ from each other.

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

State what further information is needed to calculate the relative atomic mass of gallium.

..... [1]

- (b) Gallium and its compounds show similar properties to aluminium and its compounds. Gallium reacts with excess chlorine to form gallium trichloride.

At 500 °C, gallium trichloride is a gas.

Suggest the type of attraction that exists at 500 °C

- between atoms within a gallium trichloride molecule

.....

- between gallium trichloride molecules.

.....

[2]

- (ii) When gallium trichloride is cooled a solid, Ga_2Cl_6 , forms.

Suggest the name of the attraction formed between two gallium trichloride molecules to form Ga_2Cl_6 .

..... [1]

- (c) Gallium metal reacts rapidly when exposed to air. A white solid layer is formed on its surface.

- (i) Suggest an equation to describe the reaction occurring when gallium metal is exposed to air.

..... [2]

- (ii) The table gives the formula of each gallium-containing product formed when gallium oxide reacts separately with hot aqueous hydrochloric acid and hot aqueous sodium hydroxide.

	formula of gallium-containing product
hot aqueous hydrochloric acid	GaCl_3
hot aqueous sodium hydroxide	$\text{NaGa}(\text{OH})_4$

Give the name of the type of behaviour shown by gallium oxide in these reactions.

..... [1]

[Total: 8]

Question 2

(a) The equation shown in (a)(i) describes the reaction which occurs when aqueous potassium iodide is added to aqueous copper(II) sulfate. A white precipitate of copper(I) iodide forms in a brown solution of iodine and potassium sulfate.

Balance the equation and include state symbols.



[2]

The table gives the oxidation numbers of iodine in the different species in the equation.

iodine-containing species	oxidation number of iodine
KI	-1
CuI	-1
I_2	0

- (ii) Deduce the oxidation number of copper in CuSO_4 and CuI .

- oxidation number of copper in CuSO_4
- oxidation number of copper in CuI

[1]

- (b) Describe the type of reaction shown by the equation in (a)(i). Explain your answer in terms of electron transfer.

.....

 [2]

- (iii) In the reaction described in (a)(i), a student uses 17.43 g of $\text{CuSO}_4 \cdot y\text{H}_2\text{O}$. By further titration of the reaction products the student concludes that the total amount of CuSO_4 in the sample is 0.0982 mol.

Use the *periodic table* to complete the table to calculate the value of y , where y is an integer. Show your working.

mass of 0.0982 mol CuSO_4 g
amount of H_2O in 17.43 g of $\text{CuSO}_4 \cdot y\text{H}_2\text{O}$ mol H_2O
value of y	$y = \dots\dots\dots$

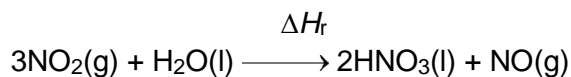
[4]

[Total: 9]

Question 3

Nitric acid, HNO_3 , can be made by reacting nitrogen dioxide with water.

The enthalpy change for the reaction can be measured indirectly using a Hess' cycle.



- (a) Explain what is meant by the term *enthalpy change of formation*.

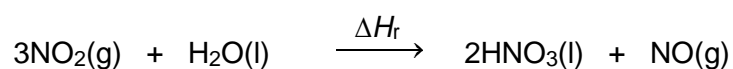
.....

 [2]

- (b) Complete the Hess' cycle using the values given in the table and hence calculate the enthalpy change, ΔH_r , for this reaction.

Show your working.

substance	$\Delta H_f / \text{kJ mol}^{-1}$
$\text{NO}_2(\text{g})$	34.0
$\text{H}_2\text{O}(\text{l})$	-286
$\text{HNO}_3(\text{l})$	-173
$\text{NO}(\text{g})$	91.1



$\Delta H_r = \dots\dots\dots \text{kJ mol}^{-1}$
[3]

- (c) Nitrogen and oxygen do not react at normal atmospheric temperatures.

Explain why.

.....

 [2]

Nitrogen oxides can be formed naturally in the Earth's atmosphere from nitrogen and oxygen in the air.

- (d) State **one** way that nitrogen oxides are produced naturally.

..... [1]

- (e) Nitrogen dioxide, NO₂, acts as a homogeneous catalyst in the oxidation of atmospheric sulfur dioxide.

- (i) Explain why NO₂ is described as a homogeneous catalyst.

.....
.....
.....
..... [3]

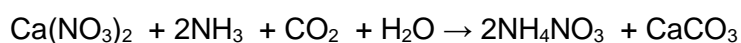
- (ii) Write equations which describe the two reactions occurring when NO₂ acts as a catalyst in the formation of sulfur trioxide from sulfur dioxide.

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

[Total: 13]

Question 4

Calcium nitrate, Ca(NO₃)₂, reacts with ammonia, carbon dioxide and water to form a mixture of ammonium nitrate and calcium carbonate.



- (a) Explain why ammonia is described as a Brønsted-Lowry base in this reaction.

..... [1]

The product mixture can then be added to soil.

- (b) State **two** reasons why this mixture of products is added to some soils.

1
2
[2]

(c) Complete the table to name the shape and give the bond angle of each species.

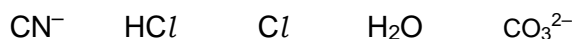
	name of shape	bond angle / °
CO ₂		
H ₂ O		
NH ₃		

[3]

Total: [6 marks]

Question 5

(a) Below is a list of species which can react with organic compounds.



i) From the list, identify a species which can react with ethane.

..... [1]

ii) From the list, identify **two** species which can attack the π bond in ethene.

..... [1]

iii) From the list, identify a species which can be used to distinguish between solutions of propanoic acid and propan-1-ol. Describe any relevant observations.

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

(iv) Cl(g) can be made from $\text{Cl}_2\text{(g)}$.

Describe the conditions required for this process.

..... [1]

(v) Name this process.

..... [1]

(b) But-1-ene reacts with steam in the presence of concentrated phosphoric acid to form two isomers of molecular formula $\text{C}_4\text{H}_{10}\text{O}$.

Each reaction occurs via a different intermediate ion.

(i) Draw the structure of both intermediate ions.

- (ii) Circle the more stable intermediate ion drawn in (d)(i). Explain your answer.

.....

 [2]

[Total: 10]

Question 6

Nitrogen, N₂, is the most abundant gas in the Earth's atmosphere and is very unreactive.

- (i) State why N₂ is very unreactive.

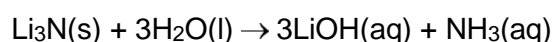
..... [1]

- (ii) Magnesium and lithium both form nitrides with N₂. These compounds both contain the N₃⁻ ion.

a. Write an equation for the reaction of magnesium with N₂ to form magnesium nitride.

..... [1]

b. Solid lithium nitride, Li₃N, reacts with water according to the following equation.



State **one** observation you would make during this reaction.

..... [1]

- (iii) State the industrial importance of ammonia.

..... [1]

- (iv) One method of producing NH₃ is by heating ammonium chloride, NH₄Cl, with CaO.



Explain why the reaction of NH₄Cl with CaO produces ammonia.

.....

 [2]

- (v) Three oxides of nitrogen, NO, NO₂ and N₂O, can be formed under different conditions.

Complete the table to give the oxidation numbers of nitrogen in NO and NO₂.

compound	NO	NO ₂
oxidation number of N		

[1]

- (vi) NO₂ can be formed by different chemical reactions.

Write equations for the formation of NO₂ by:

- (iii) the reaction of N₂ with O₂

.....

- (d) the thermal decomposition of magnesium nitrate.

.....

[2]

[Total: 9 marks]

Question 7

The elements in Group 17 of the Periodic Table are called the halogens. They form stable compounds with both metals and non-metals.

The table gives some data about F₂, HCl and CaF₂.

	F ₂	HCl	CaF ₂
boiling point / K	85	188	2773
relative formula mass	38.0	36.5	78.1

- (a) (i) State what is meant by the term *relative formula mass*.

.....

.....

..... [2]

- (ii) F₂ and HCl are both covalent molecules.

Suggest why the boiling point of HCl is higher than that of F₂.

.....

.....

..... [2]

- (iii) Explain why CaF_2 has a very high boiling point.

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

- (iv) $\text{CaF}_2(\text{aq})$ can be made by the reaction of calcium carbonate with hydrofluoric acid, $\text{HF}(\text{aq})$.

Write an equation for this reaction. Include state symbols.

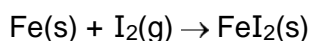
..... [2]

- (b) (i)** Complete the electronic configuration of a chloride ion.

$1s^2$ [1]

- (ii) When Cl_2 is passed over hot iron, FeCl_3 is formed.

However, when $\text{I}_2(\text{g})$ is passed over hot iron, the following reaction occurs.



State what you would observe during the reaction between Fe and I_2 . Explain why $\text{FeI}_2(\text{s})$ is formed rather than $\text{FeI}_3(\text{s})$.

observation

.....

explanation

.....

.....

[2]

- (iii)** FeI_2 is soluble in water.

A student carries out a chemical test to confirm that a solution of FeI_2 contains aqueous iodide ions, $\text{I}^-(\text{aq})$. The student adds a single reagent and a precipitate forms.

Identify the reagent the student uses. State the colour of the precipitate that forms.

reagent

colour of precipitate

[2]

- (c)** Compounds containing I^- are often contaminated by bromide ions, Br^- .

Identify a further reagent that the student could use to show that the precipitate formed in **(iii)** contained iodide ions.

..... [1]

(d) HOF is the only known molecule that contains only the elements hydrogen, oxygen and fluorine.

i) Draw a 'dot-and-cross' diagram to represent the bonding in a molecule of HOF. Show the outer shell electrons only.

[2]

ii) HOF can be made by the reaction of F_2 with ice at $-40\text{ }^{\circ}\text{C}$. The reaction is similar to the reaction of Cl_2 with cold water.

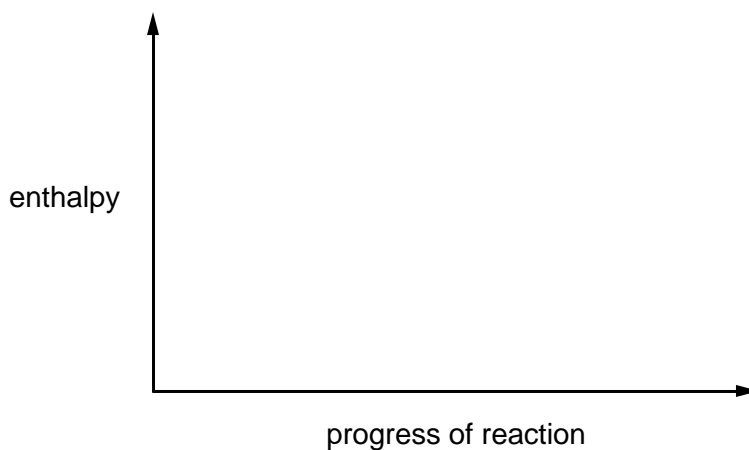
Suggest an equation for the reaction of F_2 with ice.

..... [1]

iii) HOF is an unstable compound and decomposes to form HF and O_2 .



Draw a fully labelled reaction pathway diagram on the axes provided to show the decomposition of HOF into HF and O_2 .



[2]

- (e) Pure HF is a colourless liquid at 273 K. The liquid contains HF molecules that have strong hydrogen bonds between them.

Draw a fully labelled diagram to suggest how a hydrogen bond can form between two HF molecules.

[3]

- (f) Interhalogen compounds, such as BrCl or IF_5 , contain two or more different halogen atoms that are covalently bonded.

D is an interhalogen compound that contains only chlorine and fluorine.

At 0 °C and 101 325 Pa, 1 dm³ of **D** has a mass of 4.13 g.

- i) Use the general gas equation to calculate the relative molecular mass, M_r , of **D**.

$M_r = \dots\dots\dots$
[3]

- (ii) Use your answer to (i) to determine the molecular formula of **D**.

If you were unable to calculate the M_r in (i), assume that the M_r is 130.5. This is **not** the correct value.

molecular formula of **D** = $\dots\dots\dots$
[1]

[Total: 25]

Question 8

(a) Explain what is meant by the term *relative isotopic mass*.

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

(b) A sample of copper contains two isotopes, ^{63}Cu and ^{65}Cu . The relative atomic mass of the copper in this sample is 63.55.

Calculate the percentage abundance of each of these isotopes. Show your working.

percentage abundance of ^{63}Cu = %

percentage abundance of ^{65}Cu = %
[2]

(c) (i) Name the type of bonding within a sample of solid copper.

..... [1]

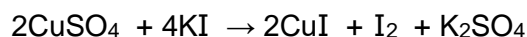
(ii) Draw a labelled diagram to show the bonding within a sample of solid copper.

[2]

(iii) State the electronic configuration of a copper atom.

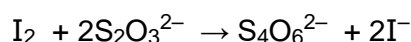
$1s^2$ [1]

- (d)** A student is provided with a sample of hydrated copper(II) sulfate, $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$, and is asked to determine the value of x .
The student dissolves a sample of the hydrated copper(II) sulfate in water and adds it to an excess of aqueous potassium iodide to make a total volume of 250.0 cm^3 of solution.



The amount of iodine produced during this reaction is found by titrating a sample of this solution with sodium thiosulfate solution.

25.0 cm^3 of the iodine-containing solution requires 20.0 cm^3 of 0.10 mol dm^{-3} sodium thiosulfate solution.



- (i) Calculate the amount, in mol, of copper(II) sulfate present in the original sample of hydrated copper(II) sulfate.

Show your working.

amount of copper(II) sulfate = mol [2]

- (iv)** A total of 7.98 g of CuSO_4 is present in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$.

Complete each row of the table to calculate the value of x , where x is an integer.

[M_r : CuSO_4 , 159.6]

amount of CuSO_4 in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ mol
amount of H_2O in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ mol
value of x	$x = \dots\dots\dots$

[3]

[Total: 13]

Question 9

A sample of barium is heated in oxygen.

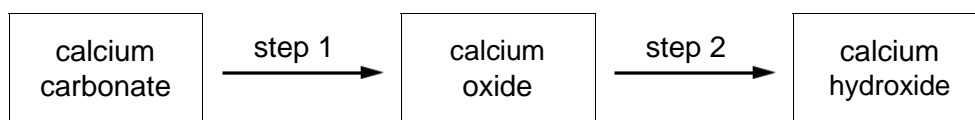
- (a) Describe **two** observations for this reaction.

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

- (b) Write an equation for this reaction. Include state symbols.

..... [1]

- (c) Calcium carbonate can be converted into calcium hydroxide in a two-step process.



- (i) Describe how the two-step process is carried out to convert calcium carbonate into calcium hydroxide. Include relevant equations.

.....
.....
.....
..... [3]

- (ii) Name the type of reaction occurring when calcium carbonate is converted into calcium oxide.

..... [1]

- (iii) State **one** common use for both calcium carbonate and calcium hydroxide.

..... [1]

(d) Gallium is a silver-grey solid. Aluminium and gallium share many similar chemical properties.

i) Construct an equation for the reaction of gallium when heated in oxygen to form gallium oxide, Ga_2O_3 .

..... [1]

ii) Deduce the oxidation number of gallium in Ga_2O_3 .

..... [1]

(e) Complete the table by predicting the formula of each gallium-containing product formed when gallium oxide reacts separately with hot aqueous hydrochloric acid and with hot concentrated sodium hydroxide.

reagents and conditions	formula of gallium-containing product
gallium oxide + hot $\text{HCl}(\text{aq})$	
gallium oxide + hot concentrated $\text{NaOH}(\text{aq})$	

[2]

[Total: 12]

Question 10

(a) The rate of chemical reactions is affected by changes in temperature and pressure.

(i) Draw a curve on the axes to show the Boltzmann distribution of energy of particles in a sample of gaseous krypton atoms at a given temperature.

Label the curve **T1** and label the axes.



[2]

]

(ii) On the diagram in (a)(i), draw a second curve to show the distribution of energies of the krypton atoms at a higher temperature.

Label the second curve **T2**.

[1]

[1]

The Boltzmann distribution assumes that the particles behave as an ideal gas.

(a) State **two** assumptions of the kinetic theory as applied to an ideal gas.

1

.....

.....

2

.....

.....

[
2
]

[2]

[Total: 5]

End of Paper