

1. (a) The compounds lithium chloride, sodium bromide and potassium iodide can be distinguished from one another by the use of flame tests.

(i) Complete the following table.

Compound	Flame colour
Lithium chloride	
Sodium bromide	
Potassium iodide	

(3)

(ii) Explain the origin of the colours in flame tests.

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 .....

(2)

- (b) These compounds can also be distinguished from one another by the use of concentrated sulphuric acid.

(i) State what would be **seen** when concentrated sulphuric acid is added to separate solid samples of each of these compounds.

Lithium chloride.....

.....

Sodium bromide.....

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Potassium iodide.....

(4)

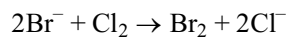
(ii) Write an equation, including the state symbols, for the reaction between solid lithium chloride and concentrated sulphuric acid.

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(2)

(Total 11 marks)

2. (a) Seawater contains aqueous bromide ions. During the manufacture of bromine, seawater is treated with chlorine gas and the following reaction occurs:



- (i) Explain the term **oxidation** in terms of electron transfer.

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(1)

- (ii) Explain the term **oxidising agent** in terms of electron transfer.

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(1)

- (iii) State which of the elements chlorine or bromine is the stronger oxidising agent and explain the importance of this in the extraction of bromine from seawater, as represented in the equation above.

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(2)

- (b) When sodium chlorate(I),  $\text{NaClO}$ , is heated, sodium chlorate(V) and sodium chloride are formed.

- (i) Write the **ionic** equation for this reaction.

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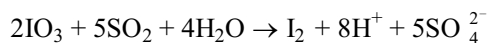
(2)

- (ii) What type of reaction is this?

.....

(1)

- (c) During one process for the manufacture of iodine the following reaction occurs:



- (i) Deduce the oxidation number of sulphur in:

$\text{SO}_2$ .....

$\text{SO}_4^{2-}$ .....

(2)

- (ii) Use your answers to part (c)(i) to explain whether  $\text{SO}_2$  has been oxidised or reduced in the above reaction.

.....

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(1)

- (iii) Name a reagent that could be used to confirm that a solution contains iodine, and state what would be **seen**.

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(2)

(Total 12 marks)

3. (a) Hydrogen chloride can be made from sodium chloride and concentrated sulphuric acid. Write a balanced chemical equation to represent this reaction.

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(1)

- (b) (i) How would you confirm that a solution said to be  $\text{HCl(aq)}$  contained chloride ions?

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(3)

- (ii) Hydrogen chloride is soluble in water. Explain why the solution is acidic.

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..... (2)

- (c) (i) Give a chemical test for chlorine, stating what you would do and what you would see.

.....  
 ..... (2)

- (ii) Hydrogen chloride can be oxidised to chlorine by lead(IV) oxide,  $\text{PbO}_2$ . Write the oxidation numbers of lead and of chlorine in the boxes provided.



(2)

- (d) Sodium iodide reacts with concentrated sulphuric acid to give iodine, not hydrogen iodide. Explain why iodides react differently from chlorides in this case.

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 .....  
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(2)  
 (Total 12 marks)

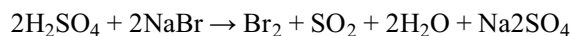
4. (a) Deduce the oxidation number of iodine in the following species.
- (i)  $I_2O_7$  ..... (1)
- (ii)  $IO_4^-$   
..... (1)
- (b) Iodine,  $I_2$ , can be reduced to iodide ions,  $I^-$ , by tin(II) ions,  $Sn^{2+}$ , which are themselves oxidised to tin(IV) ions,  $Sn^{4+}$ .
- (i) Construct the oxidation and reduction half-equations for the above system.  
.....  
..... (2)
- (ii) Use the above half-equations to construct the overall ionic equation for the reaction.  
.....  
.....  
..... (1)
- (Total 5 marks)**

5. (a) Hydrogen chloride can be prepared by reacting concentrated sulphuric acid with solid sodium chloride.

Write an equation for the reaction which occurs. State symbols are not required.

(2)

- (b) When concentrated sulphuric acid is added to solid sodium bromide, the products of the reaction include sulphur dioxide and bromine.



Sulphur and bromine change oxidation number in this reaction.

- (i) Write the oxidation numbers at the start and the end of the reaction.

Sulphur changes from ..... to .....

(1)

Bromine changes from ..... to .....

(1)

- (ii) Explain why the numbers in the balanced equation are consistent with the changes in oxidation number.

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(2)

- (c) The boiling points of three hydrogen halides are shown below

Hydrogen halide	Boiling point /K
Hydrogen chloride	188
Hydrogen bromide	206
Hydrogen iodide	238

- (i) Explain the trend in boiling point of the three hydrogen halides.

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(2)

- (ii) Predict a value for the boiling point of hydrogen fluoride. Explain your reason for choosing this value.

Predicted value .....

Explanation

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(3)

(Total 11 marks)

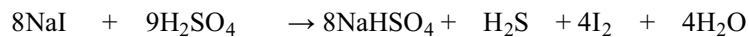
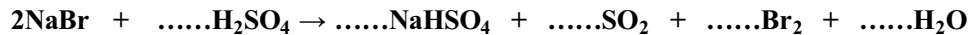
6. (a) Define **reduction** in terms of change in oxidation number.

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(1)

(b) The reaction between solid sodium halides and concentrated sulphuric acid changes as the group is descended.

(i) Complete the balancing of the equation for the reaction of **sodium bromide** with concentrated sulphuric acid.



(1)

(ii) Write the oxidation numbers of **sulphur** in the following:

$\text{H}_2\text{SO}_4$  .....

$\text{NaHSO}_4$  .....

$\text{SO}_2$  .....

$\text{H}_2\text{S}$  .....

(2)

(iii) Use the **changes** in oxidation number of **sulphur** in the reactions in (i) to show that the halides become more powerful reducing agents as the group is descended.

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(2)

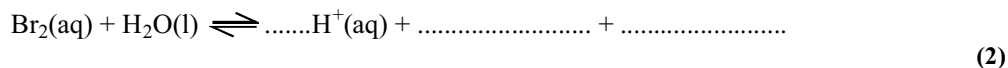
(Total 6 marks)



7. This question is about the manufacture of bromine from bromide ions found in seawater.

(a) In the first step, chlorine gas is bubbled into acidified seawater. This converts the bromide ions to bromine. The low pH prevents hydrolysis of the liberated bromine.

(i) Complete and balance the equation for the hydrolysis of bromine with water which is a disproportionation reaction.



(ii) What is the meaning of the symbol  $\rightleftharpoons$ ?

.....  
 .....

(1)

(iii) Explain, using oxidation numbers, why this reaction is known as disproportionation.

.....  
 .....  
 .....  
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(2)

(iv) Write the ionic equation, including state symbols, for the reaction of chlorine gas with bromide ions.

(2)

- (b) In the second step, air is blown through the reaction mixture to remove the bromine as a vapour which is then mixed with sulphur dioxide gas and water vapour.

The unbalanced equation for this reaction is  $\text{Br}_2 + \text{H}_2\text{O} + \text{SO}_2 \rightarrow \text{H}^+ + \text{Br}^- + \text{SO}_4^{2-}$

- (i) Identify the elements which are oxidised and reduced and give their oxidation numbers.

Element **oxidised** .....

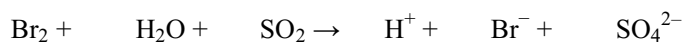
Oxidation number initial ..... final .....

Element **reduced** .....

Oxidation number initial ..... final .....

(2)

- (ii) Using this information, or otherwise, balance the equation.



(1)

(Total 10 marks)

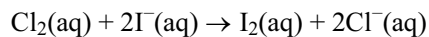
8. Which of the following statements is FALSE?

- A** iodine is more electronegative than bromine.  
**B** fluorine is more electronegative than chlorine.  
**C** metallic elements tend to react by loss of electrons.  
**D** chlorine is more electronegative than sulfur.

(Total 1 mark)

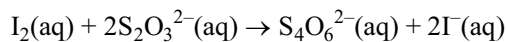
9. Chlorine was used in swimming pools as a bactericide.

The amount of chlorine present can be determined by adding excess potassium iodide solution to a known volume of swimming pool water. This reacts to form iodine:



The amount of iodine formed is then found by titration with sodium thiosulfate solution of known concentration.

The ionic equation for the reaction between iodine and sodium thiosulfate in aqueous solution is



A student carried out the determination of chlorine in a sample of swimming pool water. A record of the measurements obtained is given below:

Volume of water sample tested	=	1000 cm <sup>3</sup>
Final reading of burette	=	16.3 cm <sup>3</sup>
Initial reading of burette	=	7 cm <sup>3</sup>
Volume added from burette	=	9.3 cm <sup>3</sup>
Concentration of sodium thiosulfate solution	=	0.00500 mol dm <sup>-1</sup>

- (a) (i) The record of measurements reveals faults both in the procedure and the recording of measurements. State one fault in each of these.

Procedure .....

Recording of measurements .....

.....

(2)

- (ii) Calculate the number of moles of sodium thiosulfate used in the titration.

(1)

(iii) Use your answer to (ii) to calculate the number of moles of iodine which reacted.

(1)

(iv) Deduce the concentration of chlorine, in  $\text{mol dm}^{-3}$ , in the swimming pool water.

(1)

(b) The disinfecting action of chlorine in swimming pools is due to the presence of chloric(I) acid,  $\text{HClO}$ , formed by the reaction of chlorine with water.

In many swimming pools, chemicals other than chlorine are used to form chloric(I) acid. This is partly because the use of chlorine gas causes much more corrosion of metal parts in swimming pools than does chloric(I) acid.

Compounds used to chlorinate swimming pool water in this way include calcium chlorate(I) and chlorine dioxide.

(i) State and explain the type of reaction that occurs when chlorine attacks a metal, using the example of iron.

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(2)

(ii) Suggest **one** other reason why the use of chlorine is undesirable in swimming pools.

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(1)

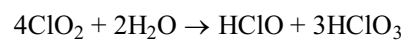
(iii) Give the formula for calcium chlorate(I).

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(1)

(iv) Chlorine dioxide,  $\text{ClO}_2$ , undergoes a disproportionation reaction when it reacts

with water.



Explain, in terms of oxidation numbers, why this is a disproportionation reaction.

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(2)

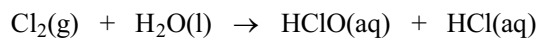


10. (a) Define the term **oxidation number**.

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.....  
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(2)

(b) The equation below shows the disproportionation of chlorine.



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(i) Underneath the chlorine-containing species write the oxidation number of chlorine in each case.

(1)

(ii) Use these oxidation numbers to explain the term **disproportionation**.

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(2)

(c) Explain why hydrogen chloride forms an acidic solution when dissolved in water.

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(2)

- (d) Outline how aqueous silver nitrate followed by aqueous ammonia may be used in the identification of chloride, bromide and iodide ions in aqueous solution.

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(6)  
(Total 13 marks)

11. Barium and magnesium are both in Group 2 of the Periodic Table. Several bottles on the Group 2 shelf of the chemicals store had damaged labels.

- (a) Two bottles are clearly labelled 'sulphate'. The solid in bottle **A** dissolves easily in water but none of the solid in bottle **B** appears to dissolve when added to water.

Which of these two bottles contains barium sulphate?.....

(1)

- (b) Bottle **C**, labelled 'magnesium carbonate', contains a white powder. When heated this powder produces a colourless gas that turns limewater cloudy.

State whether this label is correct and explain your answer.

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(2)

- (c) Describe a test to show that the solid in bottle **D** is barium hydroxide and not magnesium hydroxide.

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(3)

- (d) Bottle **E** is clearly labelled 'magnesium nitrate'. When a sample of the chemical is heated it gives off a brown gas and a gas that relights a glowing splint.



Give the name of each of the gases formed and write an equation for this chemical reaction.

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(4)  
(Total 10 marks)

12. (a) (i) State how a flame test would distinguish between samples of calcium nitrate,  $\text{Ca}(\text{NO}_3)_2$  and barium nitrate,  $\text{Ba}(\text{NO}_3)_2$ .

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(2)

- (ii) Explain the origin of the flame colour.

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(3)

- (b) Write the equation for the action of heat on barium nitrate.

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(2)

- (c) (i) What is meant by the term **polarising power** as applied to cations?

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 .....  
 .....

(2)

- (ii) Give **two** factors which affect the polarising power of cations.

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 .....

(2)

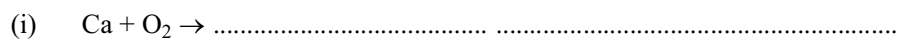
- (iii) Use this information to explain why it is easier to decompose magnesium nitrate than barium nitrate by heating.

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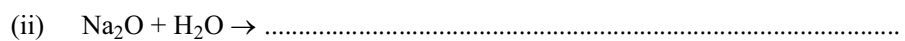
(3)

**(Total 14 marks)**

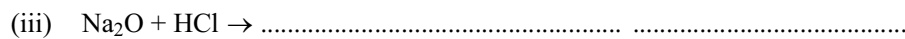
13. (a) Complete and balance the following equations:



(1)



(1)



(2)

- (b) State and explain the trend in thermal stability of the carbonates of the Group 2 elements as the group is descended.

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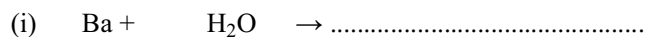
(3)  
(Total 7 marks)

14. Magnesium oxide is a basic oxide which produces an alkaline solution with water. Write an equation to show how the oxide ion,  $O^{2-}$ , acts as a base in the reaction with water.

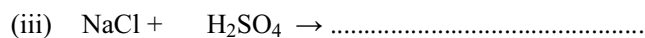
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(Total 1 mark)

15. (a) Complete and balance an equation for each of the following reactions. Do **not** include state symbols.



(1)



(1)

- (b) State the flame colours produced by compounds of:

(i) barium .....

(1)

(ii) lithium .....

(1)

- (c) Explain how compounds of elements in Groups 1 and 2 produce colours in the flame test.

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(3)

- (d) When potassium is burnt in excess oxygen, a compound is produced that contains 54.9 % potassium.

Calculate the percentage of oxygen present and hence calculate the empirical formula of this compound.

(3)

(Total 10 marks)

16. (a) Write the equations to show the action of heat on the following solid nitrates. State symbols are **not** required.

- (i) lithium nitrate,  $\text{LiNO}_3$ .

.....

(2)

- (ii) caesium nitrate,  $\text{CsNO}_3$ .

.....

(1)

- (b) The solubilities of the sulphates and hydroxides of calcium and barium are shown below. Use the information **in the table** to answer the questions that follow.

Substance	Solubility	Substance	Solubility
CaSO <sub>4</sub>	slightly soluble	Ca(OH) <sub>2</sub>	slightly soluble
BaSO <sub>4</sub>	insoluble	Ba(OH) <sub>2</sub>	soluble

- (i) Both calcium and barium metals react with water to give the metal hydroxide and hydrogen gas.

What **difference** would you expect to **see** after calcium metal and barium metal have reacted with water?

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(2)

- (ii) The reaction between barium metal and excess dilute sulphuric acid stops after a very short time. Suggest an explanation for this.

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(2)

- (c) Suggest the solubility in water of radium sulphate. Put a cross (☒) in the correct box.

<b>A</b>	Very soluble	<input checked="" type="checkbox"/>
<b>B</b>	Soluble	<input checked="" type="checkbox"/>
<b>C</b>	Slightly soluble	<input checked="" type="checkbox"/>
<b>D</b>	Insoluble	<input checked="" type="checkbox"/>

(1)

- (d) Write the **ionic** equation for the reaction of calcium metal with dilute hydrochloric acid. Include state symbols in your equation.

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(2)

(Total 10 marks)

17. (a) State the flame colours of

- (i) barium

.....

(1)

- (ii) strontium

.....

(1)

- (b) When barium is burnt in excess oxygen a compound containing 81.1% barium and 18.9% of oxygen is formed.

Calculate the empirical formula of this compound.

(2)

- (c) (i) Write the equation for the reaction of barium with water. Do **not** include any state symbols.

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(1)

- (ii) When a small piece of barium is added to water, the barium gets smaller and eventually disappears.

State TWO other observations you could make.

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(2)

- (iii) What would be the effect of adding a piece of blue litmus paper and a piece of red litmus paper to the aqueous product of the reaction in (ii)?

Red litmus .....

Blue litmus .....

(1)

**(Total 8 marks)**

18. Which concentrated acid should be used to dissolve a carbonate of a Group 2 metal to carry out a flame test?

- A ethanoic acid
- B hydrochloric acid
- C nitric acid
- D sulfuric acid

**(Total 1 mark)**

19. What colour does a barium salt give in a flame test?

- A colourless
- B green
- C red
- D yellow-red

(Total 1 mark)

20. Separate flame tests are carried out with lithium, sodium, potassium, magnesium, calcium and strontium salts. How many of these metal ions would colour the flame red?

- A 1
- B 2
- C 3
- D 4

(Total 1 mark)

21. A Group 2 element reacts vigorously with water to produce a soluble hydroxide, which forms a white precipitate when neutralised by sulfuric acid and forms a carbonate which is very stable to heat. The element could be

- A magnesium
- B calcium
- C strontium
- D barium

(Total 1 mark)



22. The Group 2 metals, considered in order of increasing atomic number, show a **decrease** in

- A first ionisation energy
- B nuclear charge
- C chemical reactivity
- D ionic radius

(Total 1 mark)