

PROSPERITY ACADEMY

**AS CHEMISTRY 9701**

**Crash Course**

RUHAB IQBAL

**GROUP 2**

**COMPLETE NOTES**



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## Group 2:-

We will only talk about Mg, Ca, Sr, Ba

Q. Why does the reactivity of Group 2 metals increase down the group?

Ans. Down the group, the nuclear charge increases but is counteracted by the increase in shielding by inner shell electrons. Therefore, the atomic radius increases as number of shells increase and it becomes easier to lose valence electrons.

→ Down the group, the metals become stronger reducing agents.  $(\text{Mg}^{\circ} + \text{Cl}_2^{\circ} \rightarrow \text{Mg}^{+2}\text{Cl}_2^{-1})$

Reactions with oxygen:- All group 2 metals react with oxygen to produce oxide which appear as white solids



Observations: Coloured flame and white solid

→ Magnesium burns with white flame, Calcium and strontium with red, and Barium with green flame.

Reactions with water:- Apart from magnesium (does react but very slowly), all group 2 metals react readily with liquid water to form hydroxide and hydrogen gas



Magnesium readily reacts with steam to form oxide and hydrogen:-  $\text{Mg}_{(s)} + \text{H}_2\text{O}_{(g)} \longrightarrow \text{MgO}_{(s)} + \text{H}_2(g)$

Observations: For Ca → Ba: solid disappears, for Mg: white solid forms. Effervescence of hydrogen and pop sound with burning splint.

Reactions with dilute acids:- All group 2 metals readily react with dilute acids to form salt and hydrogen gas.



Observations: Solid disappears, effervescence of hydrogen and pop sound with burning splint.

Reactions of Group 2 oxides with water and dilute acids:-

-  $\text{MgO}$  is insoluble in water and does not react with it

Observation: Solid disappears

- All other oxides are soluble and form hydroxides:-  $\text{XO}_{(s)} + \text{H}_2\text{O}_{(l)} \longrightarrow \text{X}(\text{OH})_{2(aq)}$  e.g.  $\text{CaO}_{(s)} + \text{H}_2\text{O}_{(l)} \longrightarrow \text{Ca}(\text{OH})_{2(aq)}$

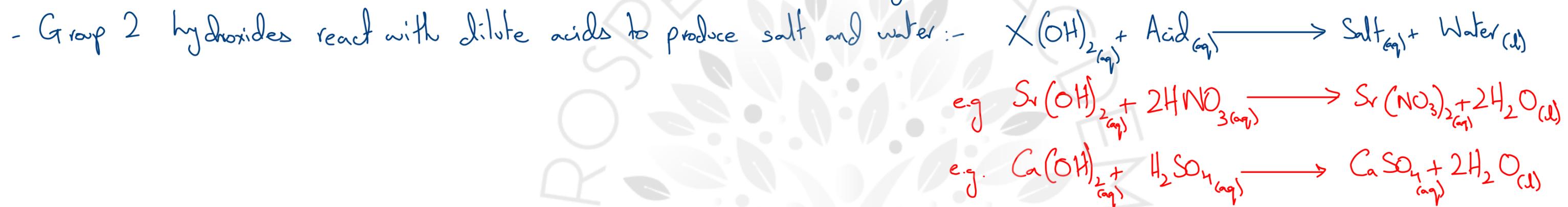
- All oxides react with dilute acids to give salt and water:-  $\text{XO} + \text{Acid} \longrightarrow \text{Salt} + \text{Water}$



Observation: Solid disappears

## Behaviour of Group 2 hydroxides with water and dilute acids:-

- Solubility of Group 2 hydroxides increases down the group:  $\text{Mg(OH)}_2$  (insoluble),  $\text{Ca(OH)}_2$  (soluble),  $\text{Sr(OH)}_2$  (more soluble),  $\text{Ba(OH)}_2$  (very soluble)
- When group 2 oxides or hydroxides dissolve in water, they give strongly alkaline solutions.



- $\text{Ca(OH)}_2$  commonly known as slaked lime can neutralise acidic soils.

## Behaviour of Group 2 carbonates and reactions with water and dilute acids:-

- None of the Group 2 carbonates is soluble in water.
- All carbonates react with dilute acids to produce salt, water and Carbon dioxide.
- All group 2 carbonates decompose on heating to give metal oxide and Carbon dioxide.
- Group 2 carbonates get more thermally stable down the group.

Observation: Solid disappears, effervescence, limewater turns milky



Observation: Solid changes colour to white, limewater turns milky

Thermal decomposition of Group 2 nitrates:- All group 2 nitrates decompose on strong heating to give metal oxide,  $\text{NO}_2$  gas and  $\text{O}_2$  gas :-  $\text{X}(\text{NO}_3)_2(\text{s}) \longrightarrow \text{XO}(\text{s}) + 2\text{NO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g})$



- Nitrates also become more thermally stable down the group

Observations: Solid changes colour, brown gas evolved, burning splint burns more brightly.

Solubility of hydroxides and sulfates:-

$\text{Mg}(\text{OH})_2$   
 $\text{Ca}(\text{OH})_2$   
 $\text{Sr}(\text{OH})_2$   
 $\text{Ba}(\text{OH})_2$  ↓  
become more soluble

$\text{MgSO}_4$   
 $\text{CaSO}_4$   
 $\text{SrSO}_4$   
 $\text{BaSO}_4$  ↓  
become less soluble

4 The metals of Group II react readily with oxygen to form compounds of general formula  $MO$ .

When each of these oxides is added to water, which forms the most alkaline solution?

- A MgO    B CaO    C SrO    **D BaO**

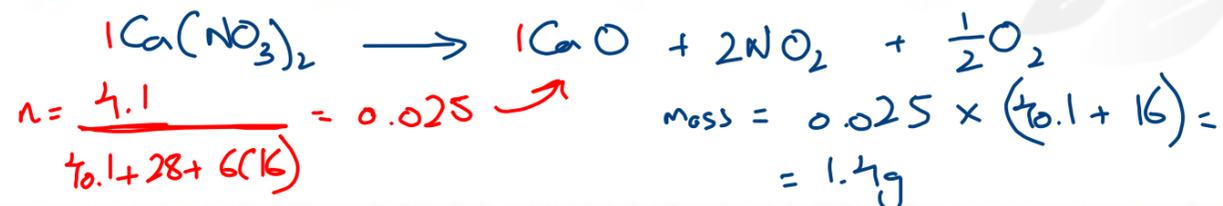
6 Steam is passed over heated magnesium to give compound **X** and hydrogen

What is **not** a property of compound **X**?

- A It has a high melting point.  
B It is a basic oxide.  
C It is a white solid.  
**D It is very soluble in water.**

9 Which mass of solid residue can be obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?

- A 0.70g    B 1.00g    **C 1.40g**    D 2.25g



12 When magnesium nitrate,  $\text{Mg(NO}_3)_2 \cdot 7\text{H}_2\text{O}$ , is heated, which three gases are given off?

- A dinitrogen oxide, oxygen, water vapour  
B hydrogen, nitrogen, oxygen  
C hydrogen, nitrogen dioxide, oxygen  
**D nitrogen dioxide, oxygen, water vapour**

21 When a mineral was heated in a Bunsen flame to constant mass, a colourless gas that turned lime water milky was evolved. The remaining solid was cooled and then added to aqueous hydrochloric acid. Vigorous effervescence was seen.

What was the mineral?

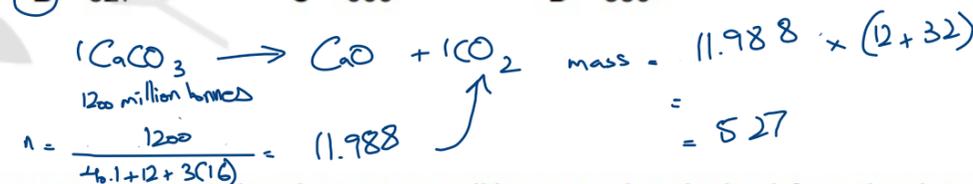
- A aragonite,  $\text{CaCO}_3 \rightarrow \text{CaO}$   
B artinite,  $\text{MgCO}_3 \cdot \text{Mg(OH)}_2 \cdot 3\text{H}_2\text{O} \Rightarrow \text{MgO} \cdot \text{Mg(OH)}_2$   
**C barytocalcite,  $\text{BaCO}_3 \cdot \text{CaCO}_3 \Rightarrow \text{BaO} \cdot \text{CaO}$**   
D dolomite,  $\text{CaCO}_3 \cdot \text{MgCO}_3 \Rightarrow \text{CaO} \cdot \text{MgO}$

24 The combustion of fossil fuels is a major source of increasing atmospheric carbon dioxide, with a consequential rise in global warming. Another significant contribution to carbon dioxide levels comes from the thermal decomposition of limestone, in the manufacture of cement and of lime for agricultural purposes.

Cement works roast 1000 million tonnes of limestone per year and a further 200 million tonnes is roasted in kilns to make lime.

What is the total annual mass output of carbon dioxide (in million tonnes) from these two processes?

- A 440    **B 527**    C 660    D 880



25 What volume of oxygen, measured under room conditions, can be obtained from the thermal decomposition of 8.2g of calcium nitrate ( $M_r = 164$ )?

- A 150 cm<sup>3</sup>    B 300 cm<sup>3</sup>    C 600 cm<sup>3</sup>    D 1200 cm<sup>3</sup>

37 Rat poison needs to be insoluble in rain water but soluble at the low pH of stomach contents.

What is a suitable barium compound to use for rat poison?

- A barium carbonate**  
B barium chloride  
C barium hydroxide  
D barium sulfate

- 61 The three minerals below are obtained from mines around the world. Each one behaves as a mixture of two carbonate compounds. They can be used as fire retardants because they decompose in the heat, producing CO<sub>2</sub>. This gas smothers the fire.

barytocite	BaCa(CO <sub>3</sub> ) <sub>2</sub>	most stable
dolomite	CaMg(CO <sub>3</sub> ) <sub>2</sub>	2nd stable
huntite	Mg <sub>3</sub> Ca(CO <sub>3</sub> ) <sub>4</sub>	least stable (more proportion of Mg)

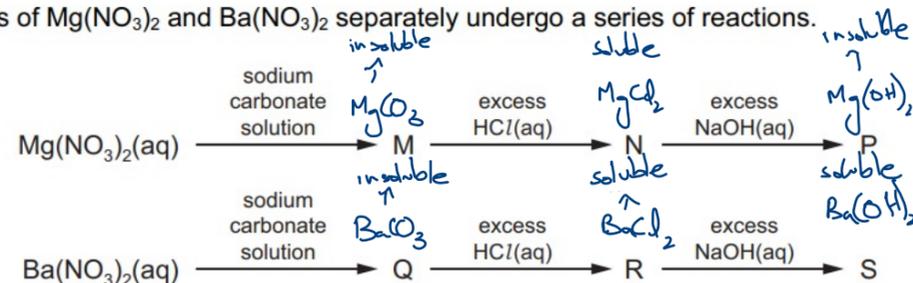
What is the order of effectiveness as fire retardant, from best to worst?

	best	→	worst
A	dolomite		barytocite
B	dolomite		huntite
C	huntite		barytocite
D	huntite		dolomite

- 72 Which property decreases on descending Group II?

- A radius of the cation, M<sup>2+</sup>  
 B reactivity of the element with water  
 C shielding of outermost electrons  
 D the ease of thermal decomposition of the carbonates, MCO<sub>3</sub>

- 79 Solutions of Mg(NO<sub>3</sub>)<sub>2</sub> and Ba(NO<sub>3</sub>)<sub>2</sub> separately undergo a series of reactions.



M, N and P are magnesium compounds.

Q, R and S are barium compounds.

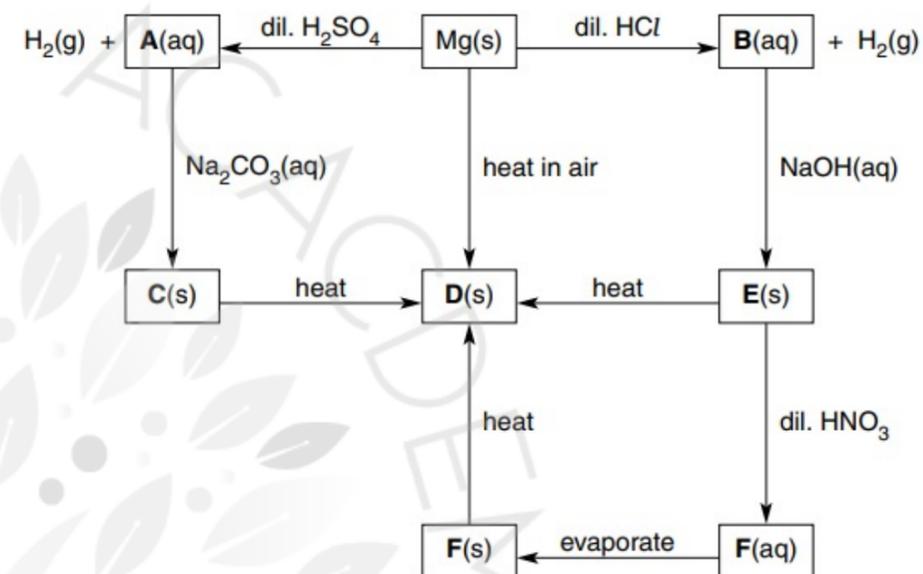
How many of M, N, P, Q, R and S are white precipitates?

- A 2      B 3      C 4      D 5

- 2 Magnesium is the eighth most common element in the Earth's crust.

The metal is widely used in alloys which are light and strong.

Some reactions of magnesium and its compounds are shown in the reaction scheme below.

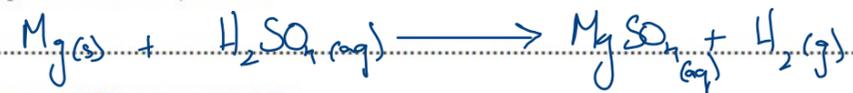


- (a) Identify, by name or formula, compounds A to F.

A MgSO<sub>4</sub>  
 B MgCl<sub>2</sub>  
 C MgCO<sub>3</sub>  
 D MgO  
 E Mg(OH)<sub>2</sub>  
 F Mg(NO<sub>3</sub>)<sub>2</sub>

- (b) (i) Construct balanced equations for the following reactions.

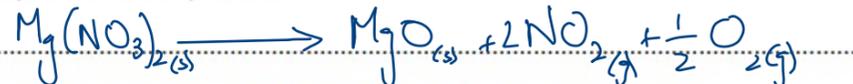
magnesium to compound A



compound C to compound D



compound F to compound D



- (ii) Suggest a balanced equation for the effect of heat on compound E.



3 Radium was discovered in the ore pitchblende by Marie and Pierre Curie in 1898, and the metal was first isolated by them in 1910.

The metal was obtained by first reacting the radium present in the pitchblende to form insoluble radium sulfate which was converted into aqueous radium bromide. This solution was then electrolysed using a mercury cathode and a carbon anode.

(a) Radium has chemical reactions that are typical of Group II metals and forms ionic compounds.

(i) What is the characteristic feature of the electronic configurations of all Group II metals?

Electronic configuration ends in  $s^2$

(ii) Radium sulfate is extremely insoluble. From your knowledge of the simple salts of Group II metals, suggest another very insoluble radium salt.

$RaCO_3$

[2]

(c) (i) Describe what you would see when magnesium reacts with cold water, slow bubbling, white solid forms

steam. silver grey metal turns white

(ii) Write an equation for the reaction with steam.



[5]

(d) Radium reacts vigorously when added to water.

(i) Write an equation, with state symbols, for this reaction.



(ii) State **two** observations that could be made during this reaction.

Vigorous effervescence and solid disappears

(iii) Suggest the approximate pH of the resulting solution.

12

(iv) Will the reaction be more or less vigorous than the reaction of barium with water?

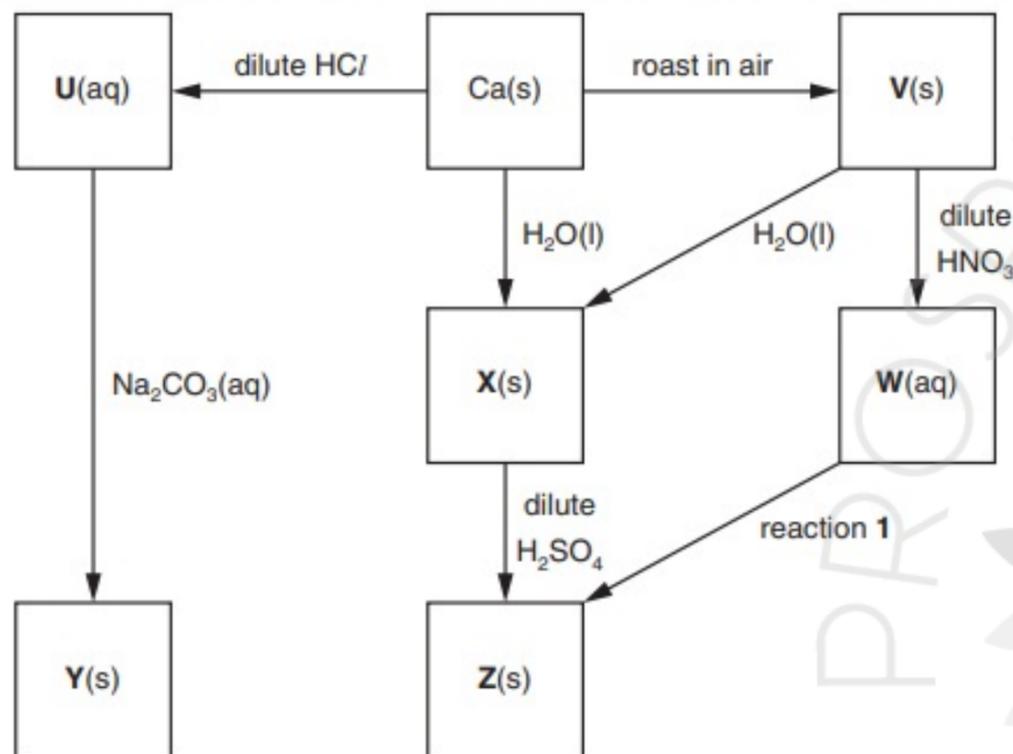
Explain your answer.

It will be more vigorous as radium has a larger radius and it is easier for it to lose its electrons

[6]

- 4 Calcium is the fifth most common element in the Earth's crust. Calcium compounds occur in bones and teeth and also in many minerals.

Some reactions of calcium and its compounds are shown in the reaction scheme below.



- (a) State the formula of **each** of the calcium compounds **U** to **Y**.

U .....  $\text{CaCl}_2$   
 V .....  $\text{CaO}$   
 W .....  $\text{Ca}(\text{NO}_3)_2$   
 X .....  $\text{Ca}(\text{OH})_2$   
 Y .....  $\text{CaCO}_3$

[5]

- (b) Compound **Y** may be converted into compound **V**. Outline how this reaction would be carried out in a school or college laboratory using a small sample of **Y**.

..... Strongly heat in a boiling tube

[1]

- (c) (i) Construct balanced equations for the following reactions.

calcium to compound **U**



compound **V** to compound **W**



compound **U** to compound **Y**



- (ii) Construct a balanced equation for the effect of heat on solid compound **W**.



- (d) Suggest the formula of an aqueous reagent, other than an acid, for reaction 1.

.....  $\text{Na}_2\text{SO}_4$  [1]

- (e) What would be observed when **each** of the following reactions is carried out in a test-tube?

the formation of **X** from **Ca(s)**

..... effervescence, solid disappears

the formation of **X** from **V**

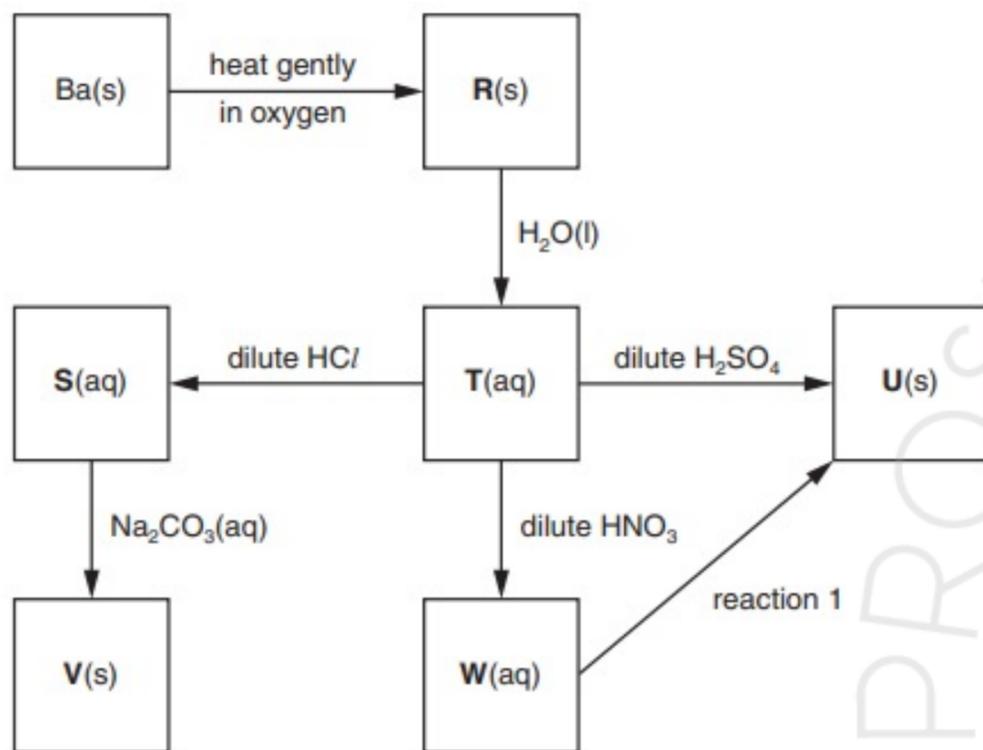
..... solid disappears

[2]

5 Barium, proton number 56, is a Group II element which occurs in nature as the carbonate or sulfate.

The element was first isolated by Sir Humphry Davy in 1808.

Some reactions of barium and its compounds are shown in the reaction scheme below.



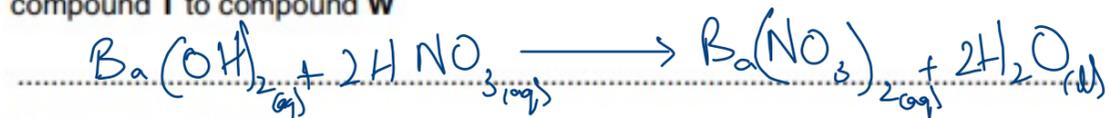
(a) State the formula of each of the barium compounds R to W.

R  $BaO$  ..... S  $BaCl_2$  .....  
 T  $Ba(OH)_2$  ..... U  $BaSO_4$  .....  
 V  $BaCO_3$  ..... W  $Ba(NO_3)_2$  .....

[6]

(b) (i) Write balanced equations for the following reactions.

compound T to compound W



the roasting of V in air



(ii) Suggest a gaseous reagent for the conversion of T into V and write a balanced equation for the reaction.

reagent  $CO_2(g)$  .....  
 equation  $Ba(OH)_2 + CO_2(g) \longrightarrow BaCO_3 + H_2O$  ..... [4]

(c) Suggest the formula of an aqueous reagent, other than an acid, for reaction 1.

$Na_2SO_4$  ..... [1]

When barium is heated strongly in oxygen, an oxide X is formed.

The oxide X contains 18.9% of oxygen by mass.

The oxide X reacts with dilute sulfuric acid in a 1:1 ratio.

Two products, one insoluble and one soluble, are formed.



(d) (i) Calculate the empirical formula of X.

$Ba : O$   
 $\frac{81.1}{137.3} : \frac{18.9}{16}$   
 $= (0.59068 : 1.18125) \div 0.59068$   
 $1 : 2$   
 $= BaO_2$

(ii) Suggest the identity of the solid Y.

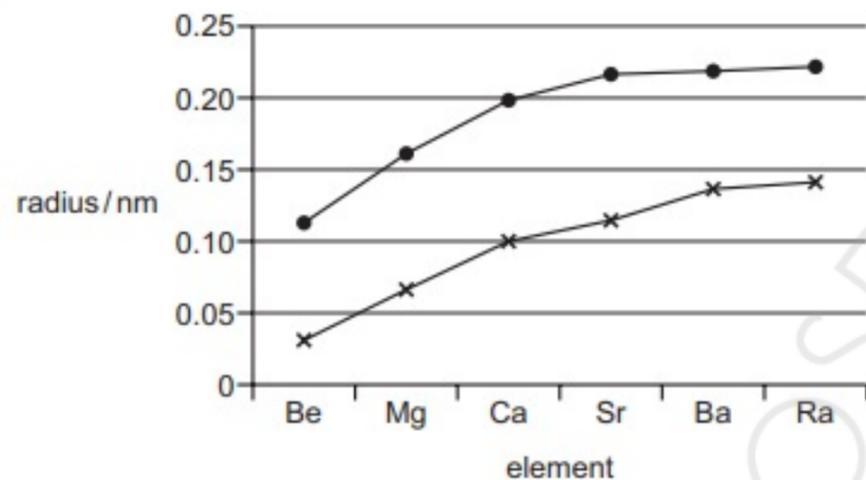
$BaSO_4$  .....

(iii) Use your answers to (i) and (ii) to construct an equation for the reaction of X with  $H_2SO_4$ .



10 The elements in Group 2 and their compounds show various trends in their physical and chemical properties.

(a) The graph below shows the radius values of the atoms and 2+ ions of the elements in Group 2.



(i) Explain why both lines show a steady increase in the values of the radii down the group.

Nuclear charge and shielding by inner electrons both increase down the group which counteract each other. As a result the radius increases due to increased number of shells [2]

(ii) State and explain which line represents the atomic radii and which represents the ionic radii.

The lower line represents ionic radii while the upper line represents atomic radii as in ionic form, the atom has lost its outer most valence shell by donating its electrons to some other species. [2]

(b) L is a salt of a Group 2 element M.

When L is heated strongly a brown gas is observed and a white solid remains.

The white solid dissolves in water to form a colourless solution of the metal hydroxide  $M(OH)_2$ .

Addition of dilute sulfuric acid to this colourless solution produces a dense white precipitate.

(i) Identify the anion in salt L.



(ii) Identify the element M and write an ionic equation for the formation of the white precipitate with sulfuric acid.

M = Ba



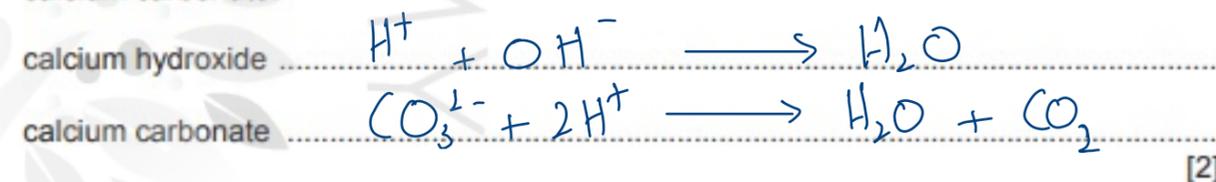
(iii) Give the formula of salt L and use it to write an equation for the thermal decomposition of salt L.

formula of salt L  $Ba(NO_3)_2$



(c) Calcium carbonate and calcium hydroxide can both be used in agriculture to neutralise acidic soils.

(i) Write ionic equations for the neutralisation of acid by each of calcium hydroxide and calcium carbonate.



(ii) Suggest and explain why calcium carbonate is a better choice than calcium hydroxide for this purpose in areas of high rainfall.

Calcium carbonate is insoluble and won't get washed away in water bodies [2]

(d) Magnesium reacts with both cold water and steam.

Give the formula of the magnesium-containing product of each of these reactions.

with cold water  $Mg(OH)_2$

with steam  $MgO$