EXAM PAPERS PRACTICE

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Detailed mark scheme

Suitable for all boards

Designed to test your ability and thoroughly prepare you

Level: CIE AS and A Level (9701)
Subject: Chemistry
Topic: CIE Chemistry
Type: Topic Question

Chemistry CIE AS & A Level
To be used for all exam preparation for 2025+

CHEMISTRY AS and A

This to be used by all students studying CIE AS and A level Chemistry (9701) But students of other boards may find it useful

Question 1.

(a) This question is about Group 2 carbonates.

Magnesium carbonate is used as an antacid and used to treat heartburn.

i) Write the chemical formula of magnesium carbonate.

[1]

ii) Write a balanced symbol equation for the reaction of magnesium carbonate with dilute nitric acid.

[2]

(3 marks)

(b) i) From the list below, identify the compound that will decompose at the lowest temperature.

- calcium carbonate
- strontium carbonate
- barium carbonate

[1]

ii) Write a balanced symbol equation for the decomposition of your chosen carbonate.

[1]

(2 marks)

(c) Group 2 nitrates become more thermally stable going down the group.

Explain why.

_____

_____

(2 marks)

Question 3.

(a) This question is about Group 2 compounds.

Strontium will react with water.

i) Write a balanced symbol equation for the reaction.

[2]

ii) Describe a test to identify the gas produced.

[1]

_____

_____

_____

(3 marks)

(b) Calcium hydroxide reacts with sulfuric acid to produce calcium sulfate and water.

i) Write the balanced symbol equation for this reaction.

[2]

ii) Describe the trend in the solubility of the Group 2 sulfates.

[1]

(3 marks)

(c) The trend in solubility of the Group 2 sulfates is due to the lattice energy, ΔH^{θ}_{latt}, and enthalpy change of hydration, ΔH^{θ}_{hyd}, of the Group 2 sulfates changing.

Describe the trend in ΔH^{θ}_{latt} and ΔH^{θ}_{hyd} of Group 2 sulfates going down Group 2.

(2 marks)

Question 3.

(a) The elements in Group 2 from Mg to Ba can be used to show the trends in properties down a group in the Periodic Table.

The Group 2 elements react with water.

i) State the trend in reactivity with water of the elements down Group 2 from Mg to Ba.

[1]

ii) Predict a possible pH for the solutions formed when Group 2 elements are added to water.

[1]

_____

_____

(2 marks)

(b) Give the **formula** of the hydroxide of the element in Group 2 from Mg to Ba that is most soluble in water.

_____

(1 mark)

(c) A trend in the thermal decomposition of Group 2 nitrates can also be observed.

i) Give the oxidation number of nitrogen in $Ca(NO_3)_2$.

[1]

ii) Write an equation for the thermal decomposition of $Ca(NO_3)_2$.

[2]

iii) State the trend in thermal stability of Group 2 nitrates.

[1]

(4 marks)

Question 4.

(a) This question is about Group 2 nitrates.

Strontium nitrate is is a Group 2 nitrate used to produce a colour in fireworks.

i) Give the formula of strontium nitrate.

[1]

ii) Give the colour that strontium nitrate will give in fireworks.

[1]

(2 marks)

(b) i) Write an equation for the reaction that occurs when strontium nitrate is heated. You should include state symbols.

[2]

ii) Give **one** observation of this reaction.

[1]

_____

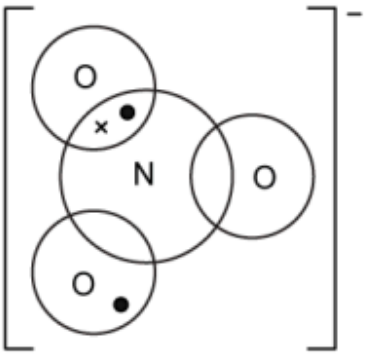
(1 mark)

(c) The nitrate ion, NO_3^-, contains a dative covalent bond.

Complete the following 'dot-and-cross' diagram of the bonding in the nitrate ion.

Use the following code for your electrons:

• electrons from oxygen
x electrons from nitrogen
□ added electron(s) responsible for the overall negative charge



(3 marks)

(d) Describe and explain the trend in thermal stabilities of the nitrates of the Group 2 elements.

(1 mark)

Question 5.

(a) Magnesium is a Group 2 metal.

Write an equation, including state symbols for the reaction between:

i) magnesium and steam

[1]

ii) magnesium and sulfuric acid

[1]

(2 marks)

(b) Magnesium sulfate is soluble in water.

Describe and explain how the solubilities of the sulfates of the Group II elements vary down the group.

(4 marks)

(c) The following table lists some enthalpy changes for magnesium and strontium compounds

Enthalpy change	Value for magnesium / kJ mol^{-1}	Value for strontium / kJ mol^{-1}
lattice enthalpy of **M**$(OH)_2$	-2993	-2467
enthalpy change of hydration of $M^{2+}(g)$	-1890	-1414
enthalpy change of hydration of $OH^-(g)$	-550	-550

Use the above data to calculate values of ΔH^{θ}_{sol} for $Mg(OH)_2$ and for $Sr(OH)_2$.

$Mg(OH)_2$ ..... kJ mol^{-1}

$Sr(OH)_2$. ..... kJ mol^{-1}

.....

.....

(2 marks)

(d) Use your results from part **(c)** to suggest whether $Sr(OH)_2$ is more or less soluble in water than in $Mg(OH)_2$ assuming all other factors are the same.

.....

.....

(2 marks)

Question 6.

(a) This question is about Group 2 carbonates.

Group 2 carbonates can react with acids.

i) Compare the reaction of calcium carbonate with hydrochloric acid and sulfuric acid.

[2]

ii) Write an equation for the reaction between calcium carbonate and sulfuric acid, including state symbols.

[1]

(3 marks)

(b) Describe and explain the trend observed in the thermal stability of the carbonates of the Group II elements.

(3 marks)

(c) The ionic radii of three ions are shown in Table 3.1.

Suggest how the thermal stabilities of zinc carbonate and lead carbonate might compare to that of calcium carbonate.

Table 3.1

Ion	Ionic radii (nm)
Ca^{2+}	0.099
Zn^{2+}	0.074
Pb^{2+}	0.120

(2 marks)

(d) Zinc is found in d block of the Periodic table but is not a transition element.

i) Explain why zinc is not classed as a transition element.

[1]

ii) Describe three characteristic chemical properties of transition elements that are not shown by Group 2 elements.

[3]

(4 marks)

Question 7.

(a) This question is about Group 2 hydroxides.

Samples of magnesium, calcium, strontium and barium are reacted with water to form their hydroxides. The resulting solutions are then filtered to collect the precipitates.

Explain the trend in the expected mass for the precipitates.

_____

_____

(2 marks)

(b) Table 4.1 shows the solubility data for the Group 2 metal hydroxides.

Table 4.1

Group 2 metal hydroxide	Solubility / g dm^{-3} at 20 °C
Magnesium hydroxide	0.140
Calcium hydroxide	1.730
Strontium hydroxide	17.70
Barium hydroxide	38.90

A student determined that a 50 cm^3 solution of an unknown Group 2 metal hydroxide contained 802 mg of the metal hydroxide.

Identify the metal hydroxide in the unknown sample.

_____

_____

(2 marks)

(c) Write an equation for the reaction between magnesium hydroxide and sulfuric acid.

You should include state symbols.

(2 marks)

(d) The solubility of Group 2 hydroxides increases going down the group because the enthalpy of solution, ΔH^{θ}_{sol}, gets more exothermic.

i) Define the term enthalpy of solution, ΔH^{θ}_{sol}.

[2]

ii) Explain why going down Group 2 the enthalpy of solution, ΔH^{θ}_{sol} gets more exothermic.

[3]

(5 marks)

Question 8.

(a) This question is about magnesium.

Magnesium forms a nitrate, $Mg(NO_3)_2$ which decomposes on heating as shown below:

$$2Mg(NO_3)_2\,(s) \rightarrow 2MgO\,(s) + 4NO_2\,(g) + O_2\,(g)$$

Using oxidation numbers, explain why the reaction involves both oxidation and reduction.

(3 marks)

(b) The values for the first, second and third ionisation energies of magnesium are shown in Table 1.1.

Table 1.1

	Ionisation energy / kJ mol^{-1}
First ionisation energy	738
Second ionisation energy	1451
Third ionisation energy	7732

i) Write an equation for the second ionisation energy of magnesium.

[2]

ii) Explain the trend in the first three ionisation energies of magnesium.

[3]

iii) Explain why magnesium has a greater second ionisation energy than barium.

[3]

(8 marks)

(c) Metal peroxides contain the $^{-}O–O^{-}$ ion.

The peroxides of the Group 2 elements, MO_2, decompose in a similar way to Group 2 metal carbonates.

i) Write an equation for the thermal decomposition of strontium peroxide, SrO_2.

[1]

ii) Suggest how the temperature at which thermal decomposition of MO_2 occurs varies down Group 2. Explain your answer.

[3]

(4 marks)

Question 9.

(a) Table 2.1 below shows the solubility data for the Group 2 metal hydroxides.

Table 2.1

Group 2 metal hydroxide	Solubility / g dm^{-3} at 20 °C
Magnesium hydroxide	0.140
Calcium hydroxide	1.730
Strontium hydroxide	17.70
Barium hydroxide	38.90

State and explain the factors responsible for the trend in the solubility of the Group 2 hydroxides.

(2 marks)

(b) Milk of magnesia, $Mg(OH)_2$ is used to neutralise stomach acid.

Explain why $Mg(OH)_2$ **cannot** be used to test for carbon dioxide but $Ba(OH)_2$ **can**.

(2 marks)

(c) i) Write an expression for the solubility product of $Sr(OH)_2$

K_{sp} =

[1]

ii) Use the data from Table 3.1 in part **(a)** to calculate the value of K_{sp} at 293 K. Include units in your answer and show your working.

K_{sp} = ... units = ...

[2]

(3 marks)

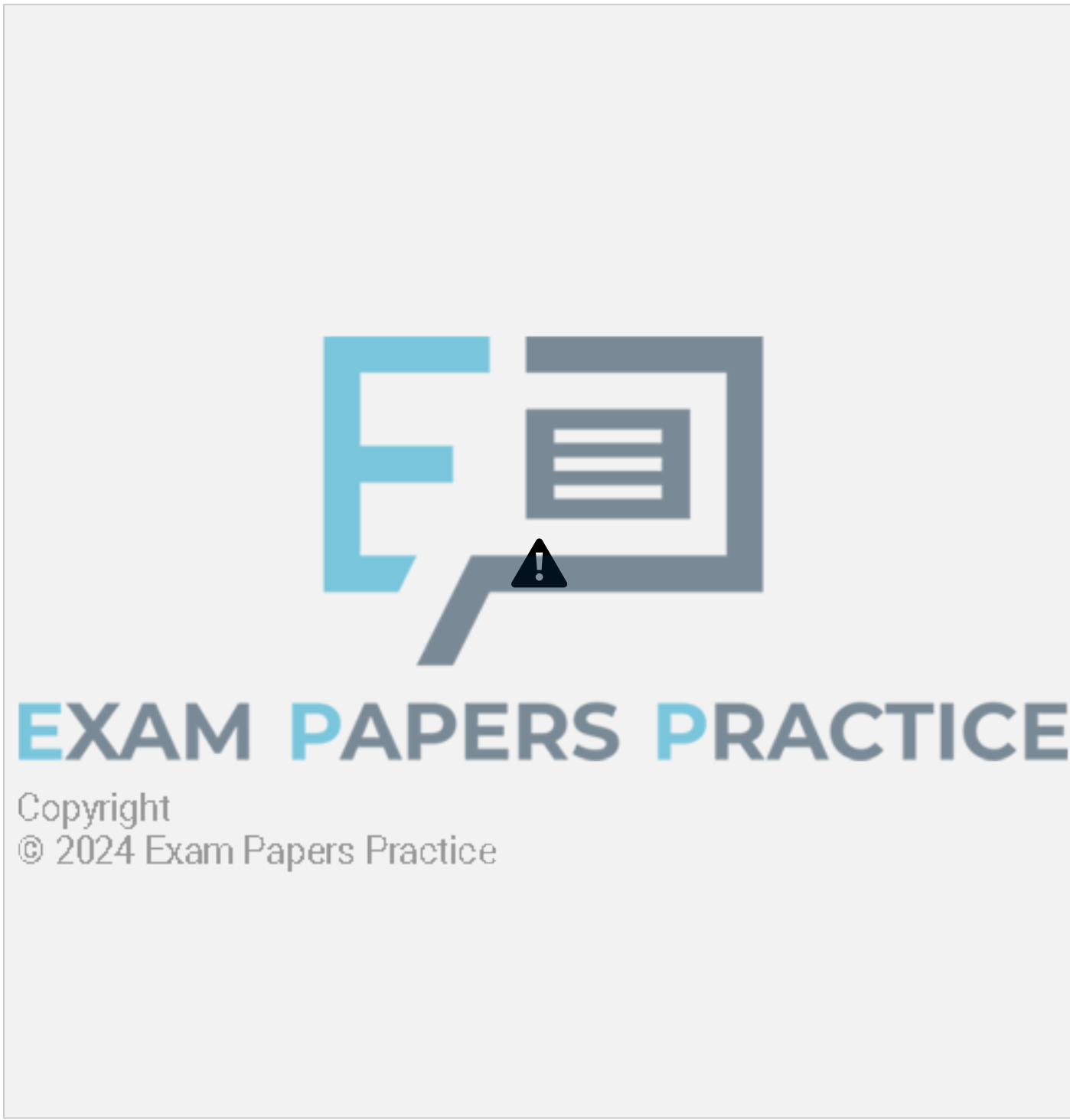
(d) Use the data from Table 3.1 in part **(a)** to calculate the pH of a saturated solution of $Mg(OH)_2$ at 293 K. Show your working.

K_w at 293 K = 0.681×10^{-14} mol^2 dm^{-6}

pH = ...

(5 marks)

Question 10.



(b) Describe and explain the trend that is observed in the thermal decomposition of the Group 2 carbonates.

(3 marks)

(c) i) Write an equation to show the equilibrium for the solubility product for $CaCO_3$. Include state symbols.

[1]

ii) With reference to your equation in part **(c)(i)**, suggest what is observed when a few cm^3 of concentrated K_2CO_3 (aq) are added to a saturated solution of $CaCO_3$. Explain your answer.

[2]

(3 marks)

(d) $CaCO_3$ has a solubility product, K_{sp} in water at 298 K of 5×10^{-9} mol^2 dm^{-6}

Calculate the solubility of $CaCO_3$ in water at 298 K, in g dm^{-3}

solubility of $CaCO_3$ = ... g dm^{-3}

(2 marks)