2 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?

....

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

....

[2]

(b) During their electrolysis of aqueous radium bromide, the Curies obtained radium at the cathode and bromine at the anode.

Write half-equations for the two electrode reactions that take place during this electrolysis.

anode ....

cathode .... [2]

(c) **(i)** Describe what you would see when magnesium reacts with

cold water, ...

....

steam. ....

....

(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.

....

....

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

………………

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

Explain your answer.

....

....

[6]

[Total: 15]

2 **(a)** **(i)** configuration ends in s^2
or there are two electrons in outermost/valence shell (1)

(ii) $RaCO_3$/radium carbonate (1) [2]

(b) anode $Br \rightarrow \frac{1}{2}Br_2 + e$ (1)
cathode $Ra^{2+} + 2e \rightarrow Ra$ (1) [2]

(c) **(i)** **water** slow reaction
gas bubbles
gas is colourless any 2 (2)

steam Mg glows
vigorous reaction
white solid formed any 2 (2)

(ii) $Mg + H_2O \rightarrow MgO + H_2$ (1) [5]

(d) **(i)** $Ra(s) + 2H_2O(l) \rightarrow Ra(OH)_2(aq) + H_2(g)$ eqn. (1)
s.s. (1)

(ii) radium dissolves/disappears
gas evolved
gas is colourless
heat evolved any 2 (2)

(iii) 10–14 (1)

(iv) more – **no mark for this alone**
because reactivity of metals increases down the Group
or electrons are further from nucleus
or IE is lower
or Ra is a stronger reducing agent (1) [6]

[Total: 15]

5 A student placed separate small samples of 1-chlorobutane, 1-bromobutane and, 1-iodobutane, in three separate test-tubes. To each test-tube, 1 cm^3 of ethanol was added, followed by 1 cm^3 of aqueous silver nitrate, $AgNO_3$. The tubes were then carefully shaken, placed in a test-tube rack and observed for 30 minutes.

A precipitate was formed in each test-tube but **not** at the same time; the fastest taking about two minutes to become opaque and the slowest about 20 minutes.

(a) What is the identity of the precipitate formed when 1-chlorobutane is used?

....[1]

(b) What will be the colour of this precipitate?

....[1]

(c) Which of the three halogenoalkanes will produce a precipitate in about two minutes?

....[1]

(d) Use appropriate data from the *Data Booklet* to explain why this reaction takes place most quickly of the three.

....

....

....[2]

[Total: 5]

4 **(a)** C : H : Br $= \frac{29.3}{12} : \frac{5.7}{1} : \frac{65.0}{79.9}$ (1)

$= 2.44 : 5.7 : 0.81$

$= 3 : 7 : 1$ (1)

$C_3H_7Br = (3 \times 12) + (7 \times 1) + 79.9 = 122.9$

use of 122.9 or 123 to prove

molecular formula must be C_3H_7Br (1) [3]

(b) **(i)** mechanism must be S_N2

dipole on C-Br bond **or**
central C atom shown with δ+ (1)

attack on C atom by lone pair of OH
not from negative charge (1)

transition state formed **with** negative charge shown (1)

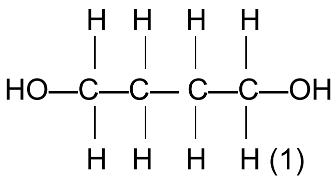
Br leaves/NaBr formed (1)

(ii) C_2H_4/ethane (1)

(iii) ethanol/C_2H_5OH (1)

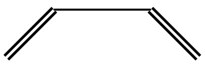
(iv) elimination (1) [7]

(c) **(i)**

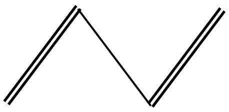


$HO-CH_2-CH_2-CH_2-CH_2-OH$ (1)

(ii) **must** be skeletal



or



(1) [2]

[Total: 12]

5 **(a)** AgC*l*/silver chloride (1) [1]

(b) white (1) [1]

(c) 1-iodobutane (1) [1]

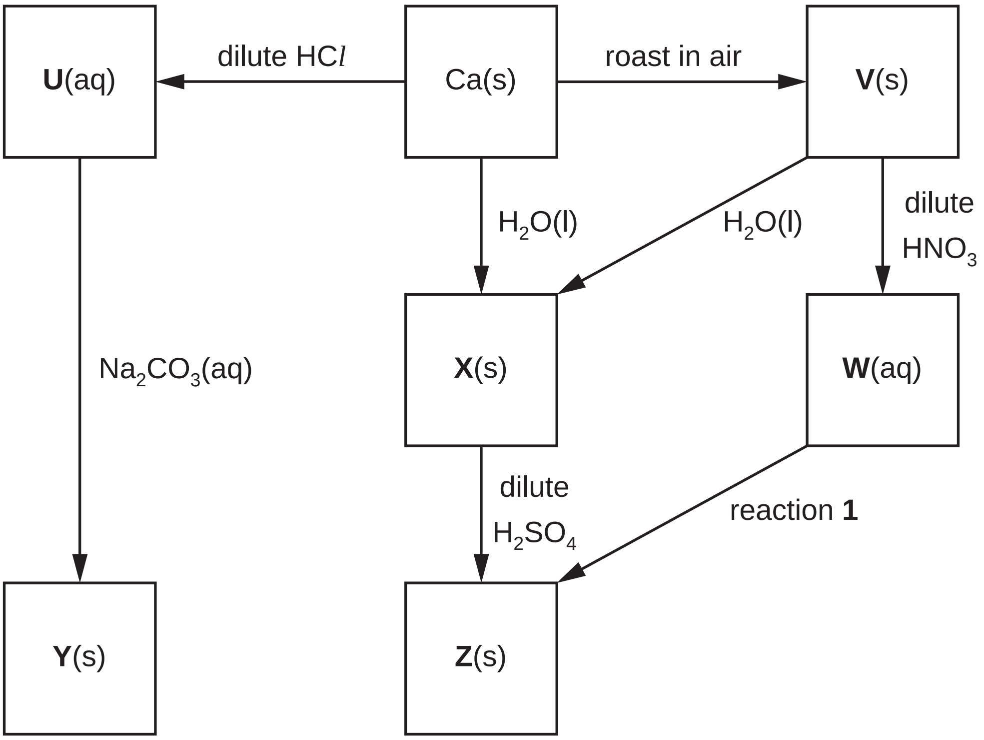
(d) C-I bond is weaker/longer than the other C-halogen bonds (1)

C-I bond energy is 240 kJ mol^{1}
or covalent radius of I is 0.133 nm (1) [2]

[Total: 5]

3 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 ....

V ....

W ....

X ....

Y .... [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**.

....

.... [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**.

....

[4]

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

.... [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)

....

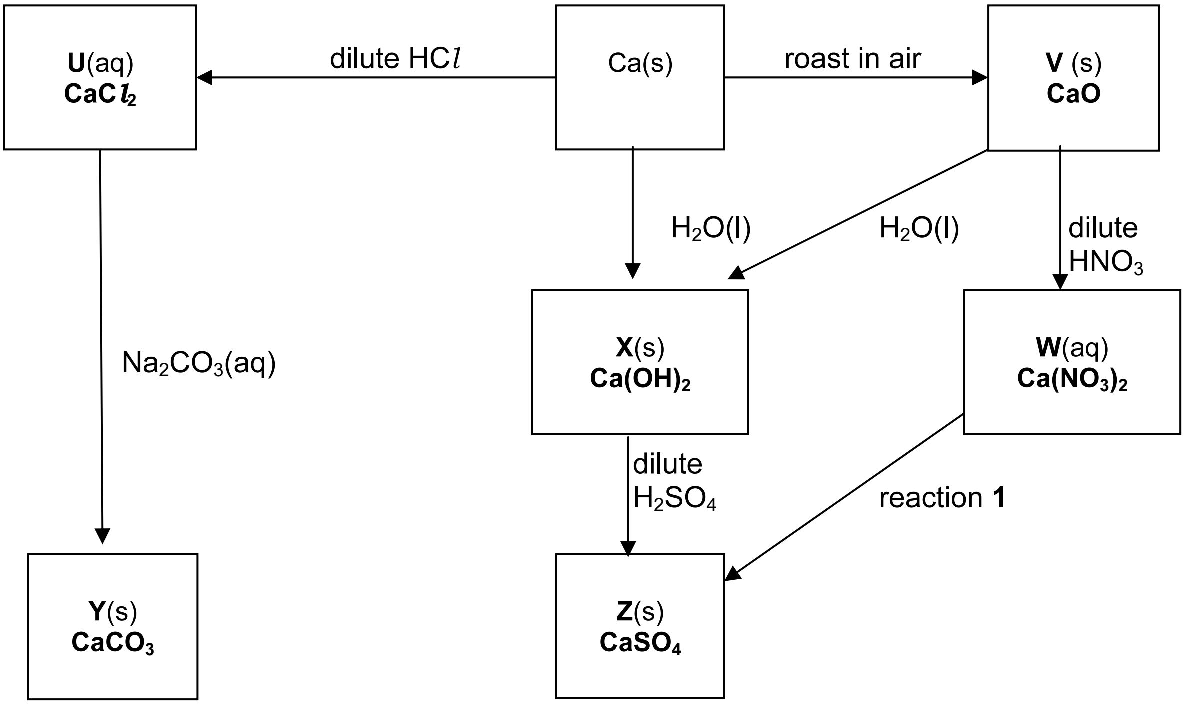
the formation of **X** from **V**

....

[2]

[Total: 13]

3



(a) **U** $CaCl_2$ (1)
V CaO (1)
W $Ca(NO_3)_2$ (1)
X $Ca(OH)_2$ (1)
Y $CaCO_3$ (1) [5]

(b) heat strongly in a test-tube or a boiling tube
do not allow 'heat gently' or 'reflux' (1) [1]

(c) **(i)** Ca to **U**
$Ca + 2HCl \rightarrow CaCl_2 + H_2$ (1)

V to **W**
$CaO + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O$ (1)

U to **Y**
$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$ (1)

(ii) $2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$ (1) [4]

(d) Na_2SO_4(aq)/K_2SO_4(aq) **or** formula of any **soluble** sulfate (1) [1]

(e) **(i)** Ca to **X**
colourless gas formed/fizzing/effervescence/bubbles **or**
Ca dissolves **or**
white precipitate/suspension formed (1)

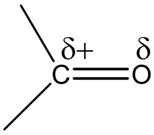
(ii) strongly exothermic/vigorous reaction **or**
steam formed/steamy fumes **or**
surface crumbles (1)
do not allow white ppt. [2]

[Total: 13]

4 **(a)** **(i)** nucleophilic addition (1)
both words are necessary

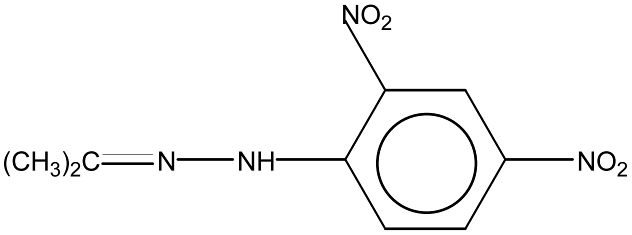
(ii) NaCN and H_2SO_4 **or**
HCN plus CN
do not allow HCN on its own (1)

(iii) correct δ+ **and** δ-, i.e.



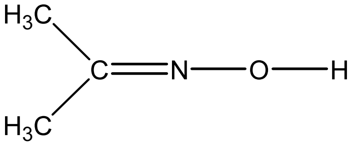
(1) [3]

(b) **(i)** correct organic product



C=N bond must be clearly shown (1)
H_2O formed/ equation balanced (1) [2]

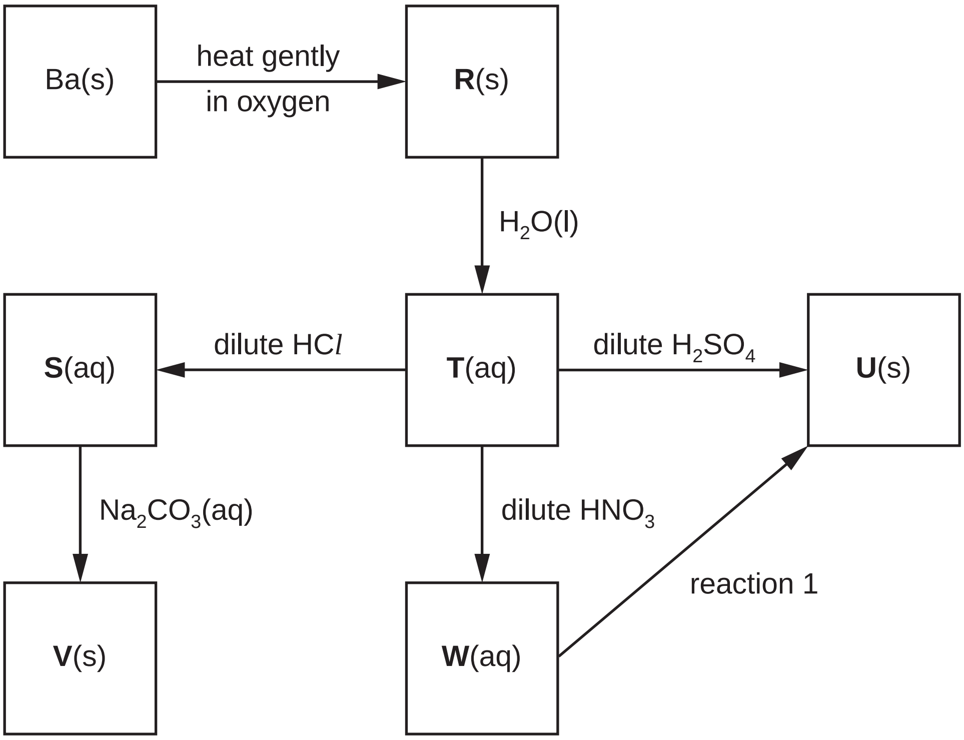
(ii)



(1) [1]

[Total: 6]

3 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 .... **S** ....

T.................................. **U** ....

V .... **W** .... [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 ....

equation ....

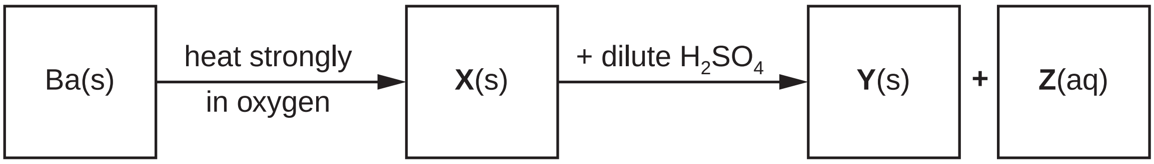
[4]

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

.... [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**.

(ii) Suggest the identity of the solid **Y**.

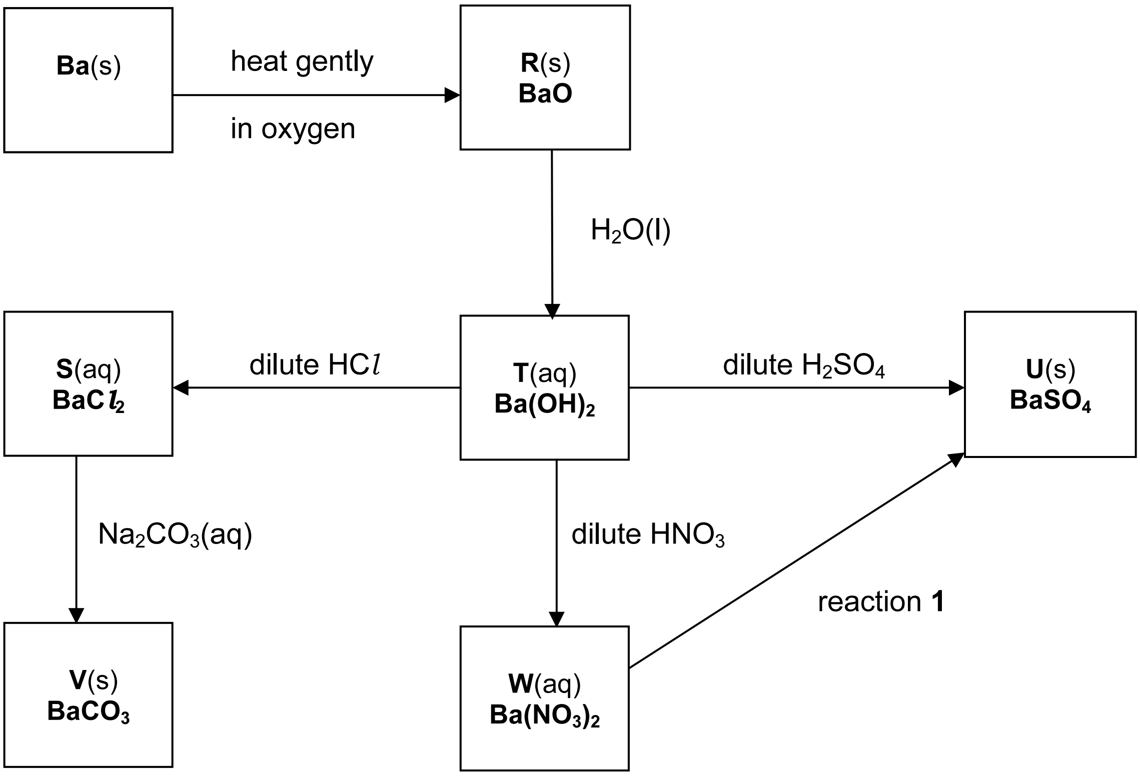
....

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

.... [4]

[Total: 15]

3



(a)

R	BaO	(1)	
S	$BaCl_2$	(1)	
T	$Ba(OH)_2$	(1)	
U	$BaSO_4$	(1)	
V	$BaCO_3$	(1)	
W	$Ba(NO_3)_2$	(1)	[6]

(b) (i) **T** to **W**

$Ba(OH)_2 + 2HNO_3 \rightarrow Ba(NO_3)_2 + 2H_2O$ (1)

heat on **V**

$BaCO_3 \rightarrow BaO + CO_2$ (1)

(ii) **T** to **V**

CO_2 (1)

$Ba(OH)_2 + CO_2 \rightarrow BaCO_3 + H_2O$ (1) [4]

(c) $Na_2SO_4(aq)/K_2SO_4(aq)$ or any soluble sulfate (1) [1]

(d) **(i)** Ba:O = $\frac{81.1}{137} : \frac{18.9}{16}$ (1)

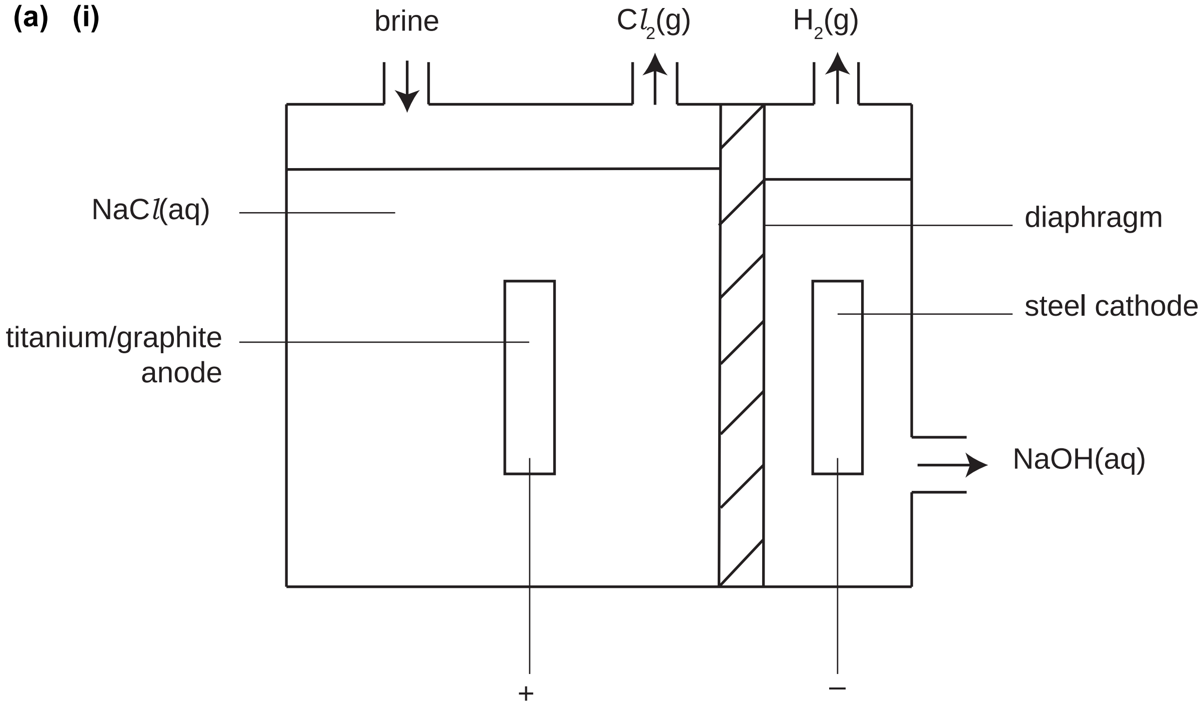
= 0.59 : 1.18
= 1 : 2
gives BaO_2 (1)

(ii) $BaSO_4$ (1)

(iii) $BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2$ (1) [4]

[Total: 15]

4 **(a)** **(i)**



titanium/graphite anode identified correctly (1)
steel cathode identified correctly (1)
diaphragm identified correctly (1)
all three outlets correctly shown (1) [4]

(ii) **anode** $2Cl\ (aq) \rightarrow Cl_2(g) + 2e$ (1)

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

or $2H_2O(l) + 2e\ \rightarrow H_2(g) + 2OH\ (aq)$ (1) [2]

(iii) sodium hydroxide (1) [1]

[Total: 7]

3 **(a)** **(i)** Describe and explain the trend observed in the thermal stability of the carbonates of the Group II elements.

....

....

....

....

....

(ii) By quoting suitable data from the *Data Booklet* suggest how the thermal stabilities of

- zinc carbonate and
- lead carbonate

might compare to that of calcium carbonate.

....

....

....

....

....

[6]

(b) Malachite is an ore of copper. It contains the following percentages by mass.

copper	57.7%
oxygen	36.2%
carbon	5.4%
hydrogen	0.9%

Malachite reacts with dilute H_2SO_4 producing a gas **B** that turns limewater milky and leaving a blue solution **C**.

When heated in the absence of air, malachite produces gas **B** and steam, and leaves a black solid **D**. **D** reacts with dilute H_2SO_4 to produce the same blue solution **C**.

Adding iron filings to **C** produces a pink solid **E** and a pale green solution **F**.

(i) Calculate the empirical formula of malachite.

....

(e) lines 1 and 2: as $[H_2O_2]$ increases by 0.07/0.05 = 1.4, so does rate
so order w.r.t. $[H_2O_2]$ = **1** [1]
lines 1 and 3: increase in rate (1.8) is also the increase in $[H_2O_2]$,
so rate is **independent** of $[H^+]$ (*or* zero order) [1]

a description can be accepted here
if both orders are correct but no working/explanation given score [1]

(f) the first step/or the relevant equation [1]

[Total: 11]

3 (a) (i) carbonates become more stable down the Group/higher decomposition temperature [1]
cation/M^{2+} radius/size increases down the group/M^{2+} charge density decreases [1]
anion/carbonate ion/CO_3^{2} suffers less polarisation/distortion [1]

(ii) ionic radii quoted: Ca^{2+}: 0.099 nm
Zn^{2+}: 0.074 nm
Pb^{2+}: 0.120 nm [1]

thus we expect $ZnCO_3$ to be less stable, but $PbCO_3$ to be more stable [1]
if candidate states $PbCO_3$ is more stable than $ZnCO_3$ (or converse) with no reference to $CaCO_3$ give [1] as salvage.

(b) (i) Cu = 57.7/63.5 = 0.91 ratios correct scores [1]
O = 36.2/16 = 2.26
C = 5.4/12 = 0.45
H = 0.9/1 = 0.90 hence $Cu_2O_5CH_2$ [1]

(ii) $Cu^{2+}(aq)$ *or* $[Cu(H_2O)_6]^{2+}$ NOT $[Cu(H_2O)_4]^{2+}$ [1]

(iii) **D** is CuO / copper(II) oxide [1]

$Cu_2O_5CH_2 \longrightarrow 2CuO + CO_2 + H_2O$ [1]
221 $\longrightarrow$ 159 (M_rs) [1]

$\therefore$ 10 $\longrightarrow$ 10 × 159/221 = 7.2 g (7.19)

if candidate thinks only CO_2 is lost, answer will be 8.0 g [1]

(iv) **E** is copper; **F** is Fe^{2+} / Fe SO_4 [1]
$Fe + Cu^{2+} \longrightarrow Fe^{2+} + Cu$ (or molecular) [1]

(v) redox/displacement [1]

(vi) blue ppt./solid formed [1]
(dissolves to give) dark blue/purple colour [1]
blue ppt. is $Cu(OH)_2(s)$ [1]
deep blue is $[Cu(NH_3)_4]^{2+}$ (allow $[Cu(NH_3)_4(H_2O)_2]^{2+}$ NOT $[Cu(NH_3)_6]^{2+}$ [1]

[Total: 19]

Section A

Answer **all** questions in the spaces provided.

1 **(a)** Describe and explain qualitatively the trend in the solubilities of the sulfates of the Group II elements.

....

....

....

....[3]

(b) The major ore of barium is barytes, $BaSO_4$. This is very unreactive, and so other barium compounds are usually made from the sulfide, BaS. This is obtained by heating the crushed ore with carbon, and extracting the BaS with water.

$$BaSO_4(s) + 4C(s) \longrightarrow BaS(s) + 4CO(g)$$

When 250 g of ore was heated in the absence of air with an excess of carbon, it was found that the CO produced took up a volume of 140 dm^3 at 450 K and 1 atm.

(i) Calculate the number of moles of CO produced.

....

(ii) Calculate the number of moles of $BaSO_4$ in the 250 g sample of the ore.

....

(iii) Calculate the percentage by mass of $BaSO_4$ in the ore.

....

[4]

1 **(a)** Sulfates become **less soluble** down the group [1]
both lattice energy and hydration (are involved) [1]
but hydration energy decreases more than lattice energy
or HE becomes less than LE *or* HE decreases whereas LE is almost constant [1]
(due to cationic radius increasing)

[3]

(b) **(i)** n(CO) = pV/RT = $1.01 \times 10^5 \times 140 \times 10\ ^3/(8.31 \times 450)$ = **3.78**

or = 140 × (273/450) / 22.4 = **3.79**

allow= 140 × (298/450) / 24.0 = 3.86 [1]

(ii) n($BaSO_4$) = n(CO)/4 = **0.945** moles (*or* 0.9475) [1]
If RTP used answer is **0.966**

(iii) M_r = 233, [1]
so 0.945 mol = 0.945 × 233 = 220g ⇒ 100 × 220/250 = **88(.07)%**
(*or* 0.9475 mol ⇒ 220.8g ⇒ 88(.3)%) [1]
If RTP used answer is **90(.0)%**

[4]

(c) **(i)** from data booklet, 1st IE = 502; 2nd IE = 966; sum = 1468 kJ mol ^{1}

so –460 = 1468 + 180 + 279 – 200 + 640 + LE
–460 = 2367 + LE
LE = **–2827** kJ mol ^{1}
(–1 for each error) [3]

(ii) LE of BaS should be smaller than that of BaO, since S^2 is bigger than O^2 . [1]
[4]

[Total: 11]

2 **(a)** Describe and explain how the solubilities of the sulfates of the Group II elements vary down the group.

....

....

....

....

....

....[3]

(b) 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 $\boldsymbol{M}(OH)_2$	–2993	–2467
enthalpy change of hydration of $\boldsymbol{M}^{2+}(g)$	–1890	–1414
enthalpy change of hydration of $OH^-(g)$	–550	–550

(i) Use the above data to calculate values of $\Delta H^{\ominus}_{solution}$ for $Mg(OH)_2$ and for $Sr(OH)_2$.

$Mg(OH)_2$ ....

....

$\Delta H^{\ominus}_{solution}$ = ... $kJ\,mol^{-1}$

$Sr(OH)_2$ ....

....

$\Delta H^{\ominus}_{solution}$ = ... $kJ\,mol^{-1}$

(ii) Use your results in **(i)** to suggest whether $Sr(OH)_2$ is more or less soluble in water than is $Mg(OH)_2$. State any assumptions you make.

....

....

(iii) Suggest whether $Sr(OH)_2$ would be more or less soluble in hot water than in cold. Explain your reasoning.

....

....

[5]

(c) Calcium hydroxide, $Ca(OH)_2$, is slightly soluble in water.

(i) Write an expression for K_{sp} for calcium hydroxide, and state its units.

K_{sp} = units ....

(ii) 25.0 cm^3 of a saturated solution of $Ca(OH)_2$ required 21.0 cm^3 of 0.0500 mol dm^{-3} HCl for complete neutralisation.

Calculate the $[OH^-(aq)]$ and the $[Ca^{2+}(aq)]$ in the saturated solution, and hence calculate a value for K_{sp}.

$[OH^-(aq)]$ = ...

$[Ca^{2+}(aq)]$ = ...

K_{sp} = ...

(iii) How would the solubility of $Ca(OH)_2$ in 0.1 mol dm^{-3} NaOH compare with that in water?
Explain your answer.

....

....

[6]

[Total: 14]

2 **(a)** less soluble down group (1)

lattice energy and hydration energies both decrease (i.e. become less negative) (1)

but H.E. decreases more (than L.E.) *or* change in H.E. outweighs L.E. (1)

so ΔH_{sol} becomes more endothermic / less exothermic (1) [4]

(b) **(i)** for Mg: $\Delta H = 2993 - 1890 - (2 \times 550) =$ **(+)3** (kJ mol ^{1}) (1)

for Sr: $\Delta H = 2467 - 1414 - (2 \times 550) =$ **–47** (kJ mol ^{1}) (1)

(ii) $Sr(OH)_2$ should be **more** soluble in water, **and** ΔH is more exothermic / negative (1)

Assuming "other factors" (e.g. ΔS, *or* temperature etc.) are the same (1)

(iii) $Sr(OH)_2$ should be **less** soluble in hot water, **because** ΔH is negative / exothermic (1) [5]

(c) **(i)** $K_{sp} = [Ca^{2+}][OH\ ]^2$ (needs the charges) units: mol^{3}dm ^{9} (1) + (1)

(ii) $n(H^+) = n(OH\ ) = 0.05 \times 21/1000 = 1.05 \times 10\ ^3$ mol in 25 cm^3

$[OH\ ] = 1.05 \times 1000/25 =$ **4.2×10^{-2}** (mol dm ^{3}) (1)

$[Ca^{2+}] =$ **2.1×10^{-2}** (mol dm ^{3}) (1)

$K_{sp} = 2.1 \times 10\ ^2 \times (4.2 \times 10\ ^2)^2 =$ **3.7×10^{-5}** (1)

(iii) **less** soluble in NaOH due to the common ion effect *or* equilibrium is shifted to the l.h.s. by high [OH] (NOT just a mention of Le Chat^r on its own) (1) [6]

[Total: 15]

4 **(a)** Write an equation representing the action of heat on calcium nitrate, $Ca(NO_3)_2$.

....

[1]

(b) Describe and explain the trend in the thermal stabilities of the nitrates of the Group II elements.

....

....

....

....

....

[3]

(c) Sodium carbonate is stable to heat, but heating lithium carbonate readily produces $CO_2(g)$.

(i) Suggest an equation for the action of heat on lithium carbonate.

....

(ii) Suggest a reason for the difference in reactivity of these two carbonates.

....

....

(iii) Predict what you would see if a sample of lithium nitrate was heated. Explain your answer.

....

....

....

[4]

[Total: 8]

4 **(a)** $Ca(NO_3)_2 \longrightarrow CaO + 2NO_2 + ½ O_2$ [1]
[1]

(b) (down the group) nitrates become **more stable** *or* require a higher temperature to decompose [1]
as size/radius of (cat)**ion** increases *or* charge density **of ion** decreases [1]
so polarisation/distortion of **anion/nitrate** decreases [1]
[3]

(c) **(i)** $Li_2CO_3 \longrightarrow Li_2O + CO_2$ [1]

(ii) radius of Li ion/Li^+ is less than that of Na ion/Na^+ (or polarising power of M^+ is greater) [1]

(iii) Brown/orange fumes/gas would be evolved *or* glowing splint relights [1]
Since the nitrate is likely to be thermally unstable *or* decomposes (just like the carbonate) *or* the balanced equation: $2LiNO_3 \longrightarrow Li_2O + 2NO_2 + ½O_2$ [1]
[4]

[Total: 8]

Section A

Answer **all** the questions in the spaces provided.

1 **(a)** **(i)** What is meant by the term *enthalpy change of hydration*, $\Delta H^{\ominus}_{\text{hyd}}$?

....

....

(ii) Write an equation that represents the $\Delta H^{\ominus}_{\text{hyd}}$ of the Mg^{2+} ion.

....

(iii) Suggest a reason why $\Delta H^{\ominus}_{\text{hyd}}$ of the Mg^{2+} ion is greater than $\Delta H^{\ominus}_{\text{hyd}}$ of the Ca^{2+} ion.

....

....

(iv) Suggest why it is impossible to determine the enthalpy change of hydration of the oxide ion, O^{2-}.

....

....

[5]

(b) The enthalpy change of solution for $MgCl_2$, $\Delta H^{\ominus}_{\text{sol}}(MgCl_2(s))$, is represented by the following equation.

$$MgCl_2(s) + aq \rightarrow Mg^{2+}(aq) + 2Cl^-(aq)$$

Describe the simple apparatus you could use, and the measurements you would make, in order to determine a value for $\Delta H^{\ominus}_{\text{sol}}(MgCl_2(s))$ in the laboratory.

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....

.... [4]

(c) The table below lists data relevant to the formation of $MgCl_2(aq)$.

enthalpy change	value / kJ mol^{-1}
$\Delta H_f^\ominus(MgCl_2(s))$	–641
$\Delta H_f^\ominus(MgCl_2(aq))$	–801
lattice energy of $MgCl_2(s)$	–2526
$\Delta H_{hyd}^\ominus(Mg^{2+}(g))$	–1890

By constructing relevant thermochemical cycles, use the above data to calculate a value for

(i) $\Delta H_{sol}^\ominus(MgCl_2(s))$,

$\Delta H_{sol}^\ominus$ = ... kJ mol^{-1}

(ii) $\Delta H_{hyd}^\ominus(Cl^-(g))$.

$\Delta H_{hyd}^\ominus$ = ... kJ mol^{-1}

[3]

(d) Describe and explain how the solubility of magnesium sulfate compares to that of barium sulfate.

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....

....

.... [4]

[Total: 16]

1 **(a)** **(i)** enthalpy/energy change/released when <u>1 mol</u> of <u>ions</u>… [1]
in the <u>gas phase</u> (are dissolved in) <u>water</u> [1]

(ii) $Mg^{2+}(g) + aq$ (*or* H_2O) $\rightarrow$ $Mg^{2+}(aq)$ *or* $[Mg(H_2O)_6]^{2+}$ [1]

(iii) Mg^{2+} has a smaller radius/size or greater charge density than Ca^{2+} (**ions** required) [1]

(iv) O^{2} reacts with water to give OH *or equation*: $O^{2} + H_2O \rightarrow 2OH$ [1]
[5]

(b) (apparatus: "insulated" calorimeter, water and thermometer)

- measure (known volume/mass of) water *or* stated volume of water (into calorimeter)
- take the temperature (of the water – NOT the $MgCl_2$)
- weigh out known mass of $MgCl_2$ *or* stated mass of $MgCl_2$
- take final/highest/constant temperature *or* record temperature change/rise 4 × [1]

[4]

(c) **(i)** $\Delta H^{\ominus}_{sol} = 641 - 801 = -160$ kJ mol ^{1} [1]

(ii) $\Delta H^{\ominus}_{hyd} = (1890 - 2526 - 160)/2 = -398$ kJ mol ^{1} [2]
[3]

(d)

- solubility: $MgSO_4 > BaSO_4$ *or* decreases down the group
- because ΔH_{sol} is more endothermic for $BaSO_4$ *or* more exothermic for $MgSO_4$
- due to larger r_{ion} *or* smaller charge density of Ba^{2+} (ion has to be mentioned)
- leading to smaller LE <u>and</u> HE *or* LE and HE decrease
- but difference in HE (between Mg^{2+} and Ba^{2+}) is larger than the difference in LE (between $MgSO_4$ and $BaSO_4$)
  or HE is dominant *or* HE decreases more than LE any 4 points [4]

[4]

[Total: 16]