8.3 Preparation of salts

01. 0620_m21_qp_42 Q: 4

A student wanted to make some zinc chloride crystals.

The student followed the procedure shown.

step 1 Add excess zinc powder to dilute hydrochloric acid to form aqueous zinc chloride.

step 2 Remove unreacted zinc powder from the aqueous zinc chloride.

step 3 Heat the solution until it is saturated.

step 4 Allow the saturated solution to cool and remove the crystals that form.

(a) Write the equation for the reaction in **step 1**. Include state symbols.

.... [3]

(b) Explain why **excess** zinc powder is added in **step 1**.

.... [1]

(c) Suggest how unreacted zinc powder is removed in **step 2**.

.... [1]

(d) A saturated solution is formed in **step 3**.

Suggest what is meant by the term *saturated solution*.

....

.... [2]

(e) Explain why crystals form as the solution cools in **step 4**.

.... [1]

(f) Name **two** zinc compounds which react with dilute hydrochloric acid to form zinc chloride.

....

.... [2]

(g) If excess calcium metal is used instead of excess zinc powder in **step 1**, pure calcium chloride crystals do **not** form.

Explain why.

....

.... [1]

(h) Some salts can be made by titration.

In a titration experiment, 20.0 cm^3 of aqueous sodium hydroxide reacts exactly with 25.0 cm^3 of 0.100 mol / dm^3 dilute sulfuric acid to make sodium sulfate.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) Circle the name of the type of reaction that takes place.

decomposition **neutralisation** **precipitation** **reduction**

[1]

(ii) Calculate the concentration of the aqueous sodium hydroxide in g / dm^3 using the following steps.

- Calculate the number of moles of dilute sulfuric acid used.

.... mol

- Determine the number of moles of sodium hydroxide which react with the dilute sulfuric acid.

.... mol

- Calculate the concentration of the aqueous sodium hydroxide in mol / dm^3.

.... mol / dm^3

- Calculate the concentration of the aqueous sodium hydroxide in g / dm^3.

.... g / dm^3
[5]

[Total: 17]

02. 0620_w21_qp_42 Q: 1

This question is about states of matter.

(a) Complete the table, using ticks (✓) and crosses (✗), to describe the properties of gases, liquids and solids.

state of matter	particles are touching	particles have random movement	particles are regularly arranged
gas			
liquid			
solid			

[3]

(b) Substances can change state.

(i) Boiling and evaporation are two ways in which a liquid changes into a gas.

Describe **two** differences between boiling and evaporation.

1 ....

2 ....
[2]

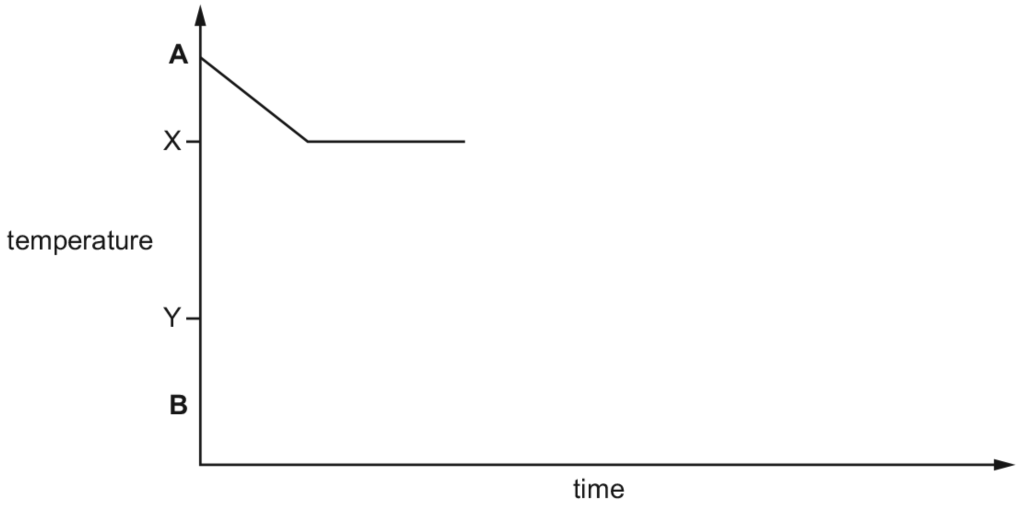
(ii) Name the change of state when:

- a gas becomes a liquid ....
- a solid becomes a gas. ....

[2]

(c) A substance boils at temperature X and melts at temperature Y.

Complete the graph to show the change in temperature over time as the substance cools from temperature **A** to temperature **B**.



[2]

(d) A solution is a mixture of a solute and a solvent.

(i) Name the process when a solid substance mixes with a solvent to form a solution.

.... [1]

(ii) Name the type of reaction when two solutions react to form an insoluble substance.

.... [1]

[Total: 11]

03. 0620_p20_qp_40 Q: 6

Soluble salts can be made using a base and an acid.

(a) Complete this method of preparing dry crystals of the soluble salt cobalt(II) chloride-6-water from the insoluble base cobalt(II) carbonate.

step 1
Add an excess of cobalt(II) carbonate to hot dilute hydrochloric acid.

step 2

....

....

step 3

....

....

step 4

....

.... [4]

(b) **(i)** 5.95 g of cobalt(II) carbonate were added to 40 cm^3 of hydrochloric acid, concentration 2.0 mol / dm^3.

Calculate the maximum yield of cobalt(II) chloride-6-water and show that the cobalt(II) carbonate was in excess.

$$CoCO_3 + 2HCl \rightarrow CoCl_2 + CO_2 + H_2O$$

$$CoCl_2 + 6H_2O \rightarrow CoCl_2.6H_2O$$

maximum yield:

number of moles of HC*l* used = ……………………………………………………….

number of moles of $CoCl_2$ formed = ……………………………………………………

number of moles of $CoCl_2.6H_2O$ formed = ……………………………………………

mass of one mole of $CoCl_2.6H_2O$ = 238 g

maximum yield of $CoCl_2.6H_2O$ = ……………………………………………………… g

to show that cobalt(II) carbonate is in excess:

number of moles of HC*l* used = ……………………………… (use your value from above)

mass of one mole of $CoCO_3$ = 119 g

number of moles of $CoCO_3$ in 5.95 g of cobalt(II) carbonate = ………………………… [5]

(ii) Explain how these calculations show that cobalt(II) carbonate is in excess.

………………………………………………………………………………………………… [1]

[Total: 10]

04. 0620_w20_qp_42 Q: 2

Soluble salts can be made by adding a metal carbonate to a dilute acid.

(a) Give the formula of the dilute acid which reacts with a metal carbonate to form a nitrate salt.

.... [1]

(b) A student wanted to make hydrated iron(II) sulfate crystals, $FeSO_4{\bullet}xH_2O$, by adding excess iron(II) carbonate to dilute sulfuric acid. The student followed the procedure shown.

step 1 Add dilute sulfuric acid to a beaker.

step 2 Add small amounts of iron(II) carbonate to the dilute sulfuric acid in the beaker until the iron(II) carbonate is in excess.

step 3 Filter the mixture formed in **step 2**.

step 4 Heat the filtrate until it is a saturated solution. Allow to cool.

step 5 Once cold, pour away the remaining solution. Dry the crystals between filter papers.

(i) Why must the iron(II) carbonate be added in excess in **step 2**?

.... [1]

(ii) State **two** observations in **step 2** that would show that iron(II) carbonate was in excess.

1 ....

2 ....
[2]

(iii) Describe what should be done during **step 3** to ensure there is a maximum yield of crystals.

.... [1]

(iv) A saturated solution is formed in **step 4**.

Describe what a saturated solution is.

....

.... [2]

(v) Name a different compound that could be used instead of iron(II) carbonate to produce hydrated iron(II) sulfate crystals from dilute sulfuric acid.

.... [1]

(c) On analysing the crystals, the student found that one mole of the hydrated iron(II) sulfate crystals, $FeSO_4$•xH2O, had a mass of 278 g.

Determine the value of *x* using the following steps:

- calculate the mass of one mole of $FeSO_4$

mass = ... g

- calculate the mass of H_2O present in one mole of $FeSO_4$•xH_2O

mass of H_2O = ... g

- determine the value of *x*.

x = ...

[3]

(d) Insoluble salts can be made by mixing solutions of two soluble salts.

A student followed the procedure shown to make silver bromide, an insoluble salt.

step 1 Add aqueous silver nitrate to a beaker. Then add aqueous potassium bromide and stir.

step 2 Filter the mixture formed in **step 1**.

step 3 Dry the residue.

(i) State the term used to describe this method of making salts.

.... [1]

(ii) Give the observation the student would make during **step 1**.

.... [1]

(iii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous potassium bromide.

Include state symbols.

.... [3]

(e) Sodium chloride is an ionic salt. It can be made by reacting sodium with chlorine gas.

The equation for this reaction is shown.

$$2\text{Na(s)} + \text{C}l_2\text{(g)} \rightarrow 2\text{NaC}l\text{(s)}$$

Calculate the volume of chlorine gas, in cm^3, that reacts to form 2.34 g of NaC*l*.

The reaction takes place at room temperature and pressure.

volume of chlorine gas = ... cm^3 [3]

(f) Sodium chloride does not conduct electricity when solid, but does conduct electricity when molten.

(i) Explain why, in terms of structure and bonding.

....

....

....

.... [3]

(ii) Name the product formed at the positive electrode when electricity is passed through molten sodium chloride.

.... [1]

(iii) State the type of change that occurs at the positive electrode in **(ii)**.

Explain your answer in terms of electron transfer.

type of change ....

explanation ....

[2]

(iv) Describe what else can be done to sodium chloride to allow it to conduct electricity.

.... [1]

[Total: 26]

05. 0620_s19_qp_42 Q: 5

Copper(II) sulfate crystals, $CuSO_4.5H_2O$, are hydrated.

Copper(II) sulfate crystals are made by reacting copper(II) carbonate with dilute sulfuric acid.

The equation for the overall process is shown.

$$CuCO_3 + H_2SO_4 + 4H_2O \rightarrow CuSO_4.5H_2O + CO_2$$

step 1 Powdered solid copper(II) carbonate is added to 50.0 cm³ of 0.05 mol / dm³ sulfuric acid until the copper(II) carbonate is in excess.

step 2 The excess of copper(II) carbonate is separated from the aqueous copper(II) sulfate.

step 3 The aqueous copper(II) sulfate is heated until the solution is saturated.

step 4 The solution is allowed to cool and crystallise.

step 5 The crystals are removed and dried.

(a) Calculate the maximum mass of the copper(II) sulfate crystals, $CuSO_4.5H_2O$, that can form using the following steps.

- Calculate the number of moles of H_2SO_4 in 50.0 cm³ of 0.05 mol / dm³ H_2SO_4.

.... mol

- Determine the number of moles of $CuSO_4.5H_2O$ that can form.

.... mol

- The M_r of $CuSO_4.5H_2O$ is 250.

  Calculate the maximum mass of $CuSO_4.5H_2O$ that can form.

.... g
[3]

(b) **Steps 1–5** were done correctly but the mass of crystals obtained was less than the maximum mass.

Explain why.

.... [1]

(c) State **two** observations that would indicate that the copper(II) carbonate is in excess in **step 1**.

1 ....

2 ....
[2]

(d) When the reaction in **step 1** is done using lumps of copper(II) carbonate instead of powder, the rate of reaction decreases. All other conditions are kept the same.

Give a reason for this. Explain your answer in terms of particles.

....

....

.... [2]

(e) Name a different substance, other than copper(II) carbonate, that could be added to dilute sulfuric acid to produce copper(II) sulfate in **step 1**.

.... [1]

(f) Name the process used to separate the aqueous copper(II) sulfate from the excess of copper(II) carbonate in **step 2**.

.... [1]

(g) The solution of aqueous copper(II) sulfate was heated until it was saturated in **step 3**.

(i) Suggest what is meant by the term *saturated solution*.

....

....

.... [2]

(ii) What evidence would show that the solution was saturated in **step 3**?

.... [1]

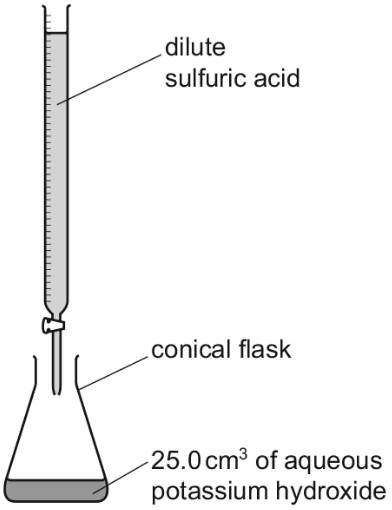
(iii) Why should the aqueous copper(II) sulfate **not** be heated to dryness in **step 3**?

.... [1]

[Total: 14]

06. 0620_w18_qp_43 Q: 4

(a) Dilute sulfuric acid and aqueous potassium hydroxide can be used to make potassium sulfate crystals using a method that includes titration.



A student titrated 25.0 cm³ of 0.0500 mol / dm³ aqueous potassium hydroxide with dilute sulfuric acid in the presence of an indicator. The volume of dilute sulfuric acid needed to neutralise the aqueous potassium hydroxide was 20.0 cm³.

The equation for the reaction is shown.

$$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$$

Determine the concentration of the dilute sulfuric acid.

- Calculate the number of moles of aqueous potassium hydroxide used.

.... mol

- Calculate the number of moles of dilute sulfuric acid needed to neutralise the aqueous potassium hydroxide.

.... mol

- Calculate the concentration of the dilute sulfuric acid.

.... mol / dm³

[3]

(b) After the titration has been completed, the conical flask contains an aqueous solution of potassium sulfate and some of the dissolved indicator.

Describe how to prepare a **pure**, dry sample of potassium sulfate crystals from new solutions of dilute sulfuric acid and aqueous potassium hydroxide of the same concentrations as used in the titration. Include a series of key steps in your answer.

....

....

....

....

....

....

.... [5]

(c) Potassium hydrogensulfate, $KHSO_4$, is an acid salt. It dissolves in water to produce an aqueous solution, **X**, containing K^+, H^+ and SO_4^{2-} ions.

Describe what you would see when the following experiments are done.

(i) Magnesium ribbon is added to an excess of solution **X**.

....

.... [2]

(ii) A flame test is done on solution **X**.

.... [1]

(iii) An aqueous solution containing barium ions is added to solution **X**.

.... [1]

(d) Dilute sulfuric acid reacts with bases, metals and carbonates.

Write chemical equations for the reaction of dilute sulfuric acid with each of the following:

(i) magnesium hydroxide

.... [2]

(ii) zinc

.... [2]

(iii) sodium carbonate

.... [2]

[Total: 18]

07. 0620_s17_qp_41 Q: 3

Magnesium sulfate and lead(II) sulfate are examples of salts.

(a) A student prepared magnesium sulfate crystals starting from magnesium carbonate. The student carried out the experiment in four steps.

step 1 The student added excess magnesium carbonate to a small volume of dilute sulfuric acid until no more magnesium carbonate would react.

step 2 The student filtered the mixture.

step 3 The student heated the filtrate obtained from **step 2** until it was saturated.

step 4 The student allowed the hot filtrate to cool to room temperature and then removed the crystals which formed.

(i) How did the student know when the reaction had finished in **step 1**?

.... [1]

(ii) Name the residue in **step 2**.

.... [1]

(iii) A saturated solution forms in **step 3**.

What is a saturated solution?

....

.... [2]

(iv) Explain why magnesium sulfate crystals form during **step 4**.

....

.... [1]

(b) Magnesium sulfate crystals are hydrated. Another student heated some hydrated magnesium sulfate crystals in a crucible and obtained the following results.

mass of hydrated magnesium sulfate crystals = 4.92 g

mass of water removed = 2.52 g

(i) Calculate the number of moles of water removed.

moles of water = ... mol [1]

(ii) Calculate the number of moles of anhydrous magnesium sulfate remaining in the crucible. The M_r of anhydrous magnesium sulfate is 120.

moles of anhydrous magnesium sulfate = ... mol [1]

(iii) Calculate the ratio of moles of anhydrous magnesium sulfate **:** moles of water. Give your answer as whole numbers.

ratio = ... **:** .... [1]

(iv) Suggest the formula of hydrated magnesium sulfate crystals.

formula of hydrated magnesium sulfate crystals = ... [2]

(c) Lead(II) sulfate, $PbSO_4$, is insoluble.

Describe how you would prepare a pure dry sample of lead(II) sulfate crystals starting from solutions of lead(II) nitrate and sodium sulfate.
Include a series of key steps in your answer.

....

....

....

....

....

....

....

.... [4]

(d) Write the ionic equation for the reaction which takes place between solutions of lead(II) nitrate and sodium sulfate.
Include state symbols.

.... [2]

[Total: 16]

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08. 0620_p16_qp_40 Q: 6

Soluble salts can be made using a base and an acid.

(a) Complete this method of preparing dry crystals of the soluble salt cobalt(II) chloride-6-water from the insoluble base cobalt(II) carbonate.

step 1
Add an excess of cobalt(II) carbonate to hot dilute hydrochloric acid.

step 2

....

....

step 3

....

....

step 4

....

.... [4]

(b) **(i)** 5.95 g of cobalt(II) carbonate were added to 40 cm^3 of hydrochloric acid, concentration 2.0 mol / dm^3.

Calculate the maximum yield of cobalt(II) chloride-6-water and show that the cobalt(II) carbonate was in excess.

$$CoCO_3 + 2HCl \rightarrow CoCl_2 + CO_2 + H_2O$$

$$CoCl_2 + 6H_2O \rightarrow CoCl_2.6H_2O$$

maximum yield:

number of moles of HCl used = ……………………………………………………………

number of moles of $CoCl_2$ formed = ……………………………………………………

number of moles of $CoCl_2.6H_2O$ formed = ……………………………………………

mass of one mole of $CoCl_2.6H_2O$ = 238 g

maximum yield of $CoCl_2.6H_2O$ = …………………………………………………… g

to show that cobalt(II) carbonate is in excess:

number of moles of HCl used = ………………………………… (use your value from above)

mass of one mole of $CoCO_3$ = 119 g

number of moles of $CoCO_3$ in 5.95 g of cobalt(II) carbonate = ………………………… [5]

(ii) Explain how these calculations show that cobalt(II) carbonate is in excess.

.... [1]

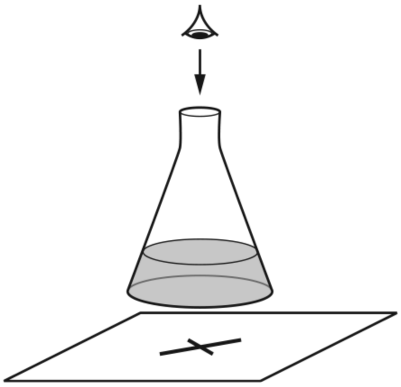
[Total: 10]

09. 0620_s16_qp_41 Q: 3

When aqueous sodium thiosulfate and dilute hydrochloric acid are mixed, a precipitate of insoluble sulfur is produced. This makes the mixture difficult to see through.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow S(s) + 2NaCl(aq) + H_2O(l) + SO_2(g)$$

The time taken for the cross to disappear from view is measured.



A student adds the following volumes of aqueous sodium thiosulfate, dilute hydrochloric acid and distilled water to the conical flask.

The time taken for the formation of the precipitate of sulfur to make the cross disappear from view is recorded.

experiment number	volume of sodium thiosulfate / cm^3	volume of hydrochloric acid / cm^3	volume of distilled water / cm^3	time taken for cross to disappear from view / s
1	10	10	40	56
2	20	10	30	28
3				

(a) State the order in which the aqueous sodium thiosulfate, hydrochloric acid and distilled water should be added to the flask.

....

.... [1]

(b) In experiment 3 the student wanted the sodium thiosulfate to be double the concentration used in experiment 2.

(i) Complete the table to show the **volumes** which should be used and the **expected** time taken for the cross to disappear from view in experiment 3. [2]

(ii) Use collision theory to explain why increasing the concentration of sodium thiosulfate would change the rate of reaction.

....

....

....

.... [2]

(c) The student repeated experiment 1 at a higher temperature.

Use collision theory to explain why the rate of reaction would increase.

....

....

....

.... [3]

[Total: 8]

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10. 0620_s16_qp_43 Q: 4

(a) Potassium iodide is an ionic compound.

(i) Describe what happens, in terms of electron loss and gain, when a potassium atom reacts with an iodine atom.

....

....

....

.... [2]

(ii) Describe the structure of solid potassium iodide. You may draw a diagram.

....

....

.... [2]

(iii) Explain why potassium iodide has a high melting point.

....

....

.... [2]

(b) Potassium iodide and lead nitrate are both soluble. Lead iodide is insoluble.

(i) Describe how a pure dry sample of lead iodide could be made from solid potassium iodide and solid lead nitrate.

....

....

....

....

....

.... [4]

(ii) Write an ionic equation for the formation of lead iodide, PbI_2, when potassium iodide and lead nitrate react with each other.
State symbols are **not** required.

.... [2]

(c) When chlorine gas is bubbled through an aqueous solution of potassium iodide, a redox reaction takes place.

$$2I^- + Cl_2 \rightarrow I_2 + 2Cl^-$$

(i) State the colour change expected in this reaction.

start colour ....

end colour ....
[2]

(ii) Identify the reducing agent in this reaction. Explain your answer.

....

....

.... [2]

[Total: 16]

11. 0620_w16_qp_43 Q: 2

Beryllium is a metallic element in Group II.

(a) Give the electronic structure of a beryllium atom.

.... [1]

(b) Give the formula of beryllium oxide.

.... [1]

(c) **(i)** Describe the bonding in a metallic element such as beryllium.
Include a labelled diagram and any appropriate charges in your answer.

....

....

.... [3]

(ii) Explain why metallic elements, such as beryllium, are good conductors of electricity.

....

.... [1]

(d) Beryllium hydroxide is amphoteric.
Beryllium hydroxide reacts with acids. The salts formed contain positive beryllium ions.

(i) Give the formula of the positive beryllium ion.

.... [1]

(ii) Write a chemical equation for the reaction between beryllium hydroxide and hydrochloric acid.

.... [2]

(iii) Beryllium hydroxide also reacts with alkalis. The salts formed contain beryllate ions, BeO_2^{2-}.

Suggest a chemical equation for the reaction between beryllium hydroxide and sodium hydroxide solution.

.... [2]

[Total: 11]

12. 0620_s15_qp_31 Q: 6

Acid-base reactions are examples of proton transfer.

(a) Ethylamine is a weak base and sodium hydroxide is a strong base.

(i) In terms of proton transfer, explain what is meant by the term *weak base*.

....

.... [2]

(ii) Given aqueous solutions of both bases, describe how you could show that sodium hydroxide is the stronger base. How could you ensure a 'fair' comparison between the two solutions?

....

....

....

.... [3]

(b) Ethylamine reacts with acids to form salts.

$$CH_3CH_2NH_2 + HCl \rightarrow \underset{\text{ethylammonium chloride}}{CH_3CH_2NH_3Cl}$$

(i) Complete the equation for the reaction between sulfuric acid and ethylamine. Name the salt formed.

$$......CH_3CH_2NH_2 + ... \rightarrow ....$$

name of salt .... [3]

(ii) Amines and their salts have similar chemical properties to ammonia and ammonium salts.

Suggest a reagent that could be used to displace the weak base, ethylamine, from its salt ethylammonium chloride.

.... [1]

(c) Gases diffuse, which means that they move to occupy the total available volume.

(i) Explain, using kinetic particle theory, why gases diffuse.

....

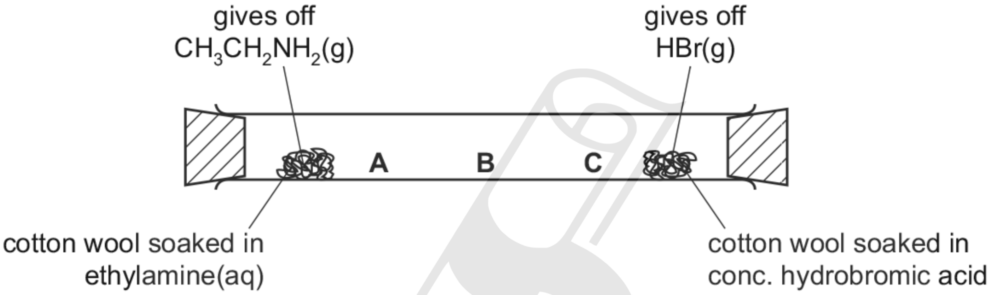
....

.... [2]

(ii) When the colourless gases hydrogen bromide and ethylamine come into contact, a white solid is formed.

$$CH_3CH_2NH_2(g) + HBr(g) \rightarrow \underset{\text{white solid}}{CH_3CH_2NH_3Br(s)}$$

The following apparatus can be used to compare the rates of diffusion of the two gases ethylamine and hydrogen bromide.



Predict at which position, **A**, **B** or **C**, the white solid will form. Explain your choice.

....

....

.... [3]

[Total: 14]

13. 0620_s15_qp_32 Q: 5

Three common methods of preparing salts are shown below.

method A adding an excess of an insoluble base or carbonate or metal to a dilute acid and removing excess by filtration

method B using a burette and indicator

method C mixing two solutions to obtain the salt by precipitation

For each of the following salt preparations, choose a method, **A**, **B** or **C**. Name any additional reagent which is needed and complete the equation.

(a) the soluble salt, nickel chloride, from the insoluble compound nickel carbonate

method ....

reagent ....

word equation ....

[3]

(b) the insoluble salt, lead(II) bromide, from aqueous lead(II) nitrate

method ....

reagent ....

ionic equation .... + ... → $PbBr_2$

[3]

(c) the soluble salt, lithium sulfate, from the soluble base lithium hydroxide

method ....

reagent ....

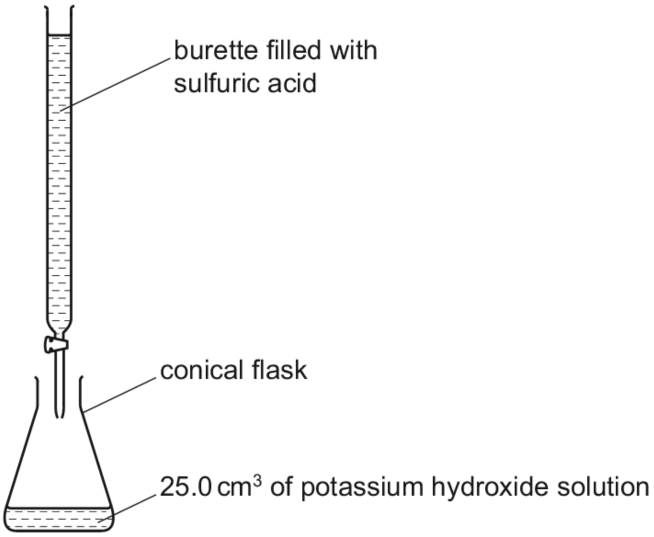
equation ....

[4]

[Total: 10]

14. 0620_w15_qp_33 Q: 7

Two salts can be made from potassium hydroxide and sulfuric acid. They are potassium sulfate, K_2SO_4, and the acid salt potassium hydrogen sulfate, $KHSO_4$. They are both made by titration.



(a) 25.0 cm^3 of potassium hydroxide, concentration 2.53 mol / dm^3, was neutralised by 28.2 cm^3 of dilute sulfuric acid.

$$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

Calculate the concentration of the sulfuric acid.

number of moles of KOH used = ...

number of moles of H_2SO_4 needed to neutralise the KOH = ...

concentration of dilute sulfuric acid = ... mol / dm^3

[3]

(b) In the conical flask there is a neutral solution of potassium sulfate which still contains the indicator used in the titration.

(i) Describe how you could obtain a solution of potassium sulfate without the indicator.

....

.... [2]

(ii) Potassium hydrogen sulfate can be made by the following reaction.

$$KOH(aq) + H_2SO_4(aq) \rightarrow KHSO_4(aq) + H_2O(l)$$

Suggest how you could make a solution of potassium hydrogen sulfate without using an indicator.

....

....

.... [2]

(c) Describe a test which would distinguish between aqueous solutions of potassium sulfate and sulfuric acid.

test ....

result ....
[2]

[Total: 9]

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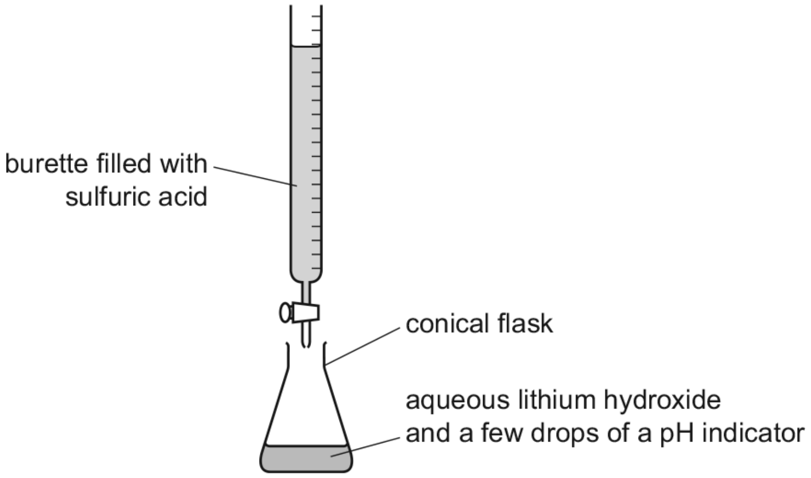
15. 0620_s14_qp_32 Q: 7

The soluble salt hydrated lithium sulfate is made by titration from the soluble base lithium hydroxide.



(a) The sulfuric acid is added slowly from the burette until the indicator just changes colour. The volume of sulfuric acid needed to just neutralise the lithium hydroxide is noted.
Describe how you would continue the experiment to obtain pure dry crystals of hydrated lithium sulfate.

....

....

....

....

....

.... [5]

(b) Using 25.0 cm^3 of aqueous lithium hydroxide, concentration 2.48 mol/dm^3, 2.20 g of hydrated lithium sulfate was obtained.
Calculate the percentage yield, giving your answer to **one** decimal place.

$$2LiOH + H_2SO_4 \rightarrow Li_2SO_4 + 2H_2O$$

$$Li_2SO_4 + H_2O \rightarrow Li_2SO_4.H_2O$$

Number of moles of LiOH used = ...

Number of moles of $Li_2SO_4.H_2O$ which could be formed = ...

Mass of one mole of $Li_2SO_4.H_2O$ = 128 g

Maximum yield of $Li_2SO_4.H_2O$ = ... g

Percentage yield = ...% [4]

(c) An experiment was carried out to show that the formula of the hydrated salt is $Li_2SO_4.H_2O$. A sample of the hydrated salt was weighed and its mass recorded. It was then heated and the anhydrous salt was weighed. This procedure was repeated until two consecutive masses were the same. This procedure is called 'heating to constant mass'.

(i) What is the reason for heating to constant mass?

.... [1]

(ii) The mass of the hydrated salt is m_1 and the mass of the anhydrous salt is m_2. Explain how you could show that the hydrated salt has **one** mole of water of crystallisation per mole of the anhydrous salt.

....

....

.... [3]

[Total: 13]

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16. 0620_w14_qp_32 Q: 1

An important aspect of chemistry is purity and methods of purification.

(a) Give an example of substances used in everyday life which must be pure.

.... [1]

(b) A list of techniques used to separate mixtures is given below.

chromatography **crystallisation** **diffusion** **dissolving**

evaporation **filtration** **fractional distillation** **simple distillation**

(i) From the list, choose the most suitable technique to separate the following.

water from sea-water ....

helium from a mixture of helium and methane ....

ethanol from a mixture of ethanol and propanol ....

iron filings from a mixture of iron filings and water ....

a mixture of two amino acids, glycine and alanine ....

[5]

(ii) Describe how you would obtain a pure sample of copper(II) sulfate-5-water crystals from a mixture of copper(II) sulfate-5-water with copper(II) oxide using some of the techniques listed above.

....

....

....

....

.... [4]

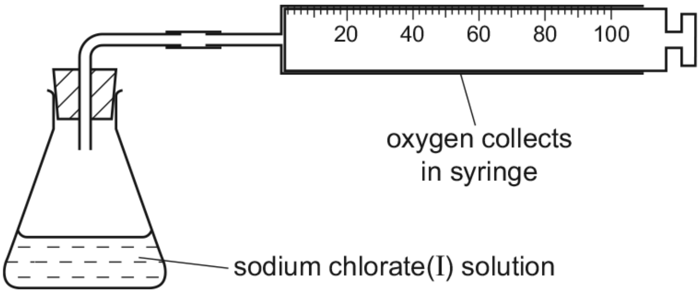
[Total: 10]

17. 0620_w14_qp_33 Q: 5

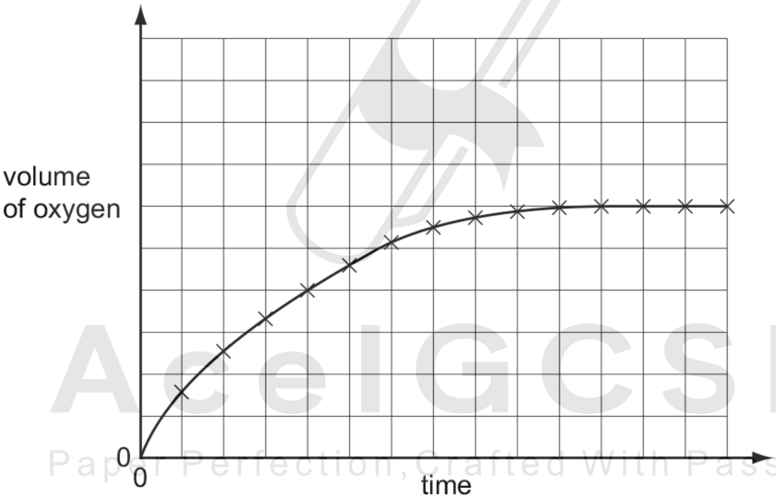
(a) Sodium chlorate(I) decomposes to form sodium chloride and oxygen. The rate of this reaction is very slow at room temperature provided the sodium chlorate(I) is stored in a dark bottle to prevent exposure to light.

$$2NaClO \rightarrow 2NaCl + O_2$$

The rate of this decomposition can be studied using the following experiment.



Sodium chlorate(I) is placed in the flask and 0.2 g of copper(II) oxide is added. This catalyses the decomposition of the sodium chlorate(I) and the volume of oxygen collected is measured every minute. The results are plotted to give a graph of the type shown below.



(i) Explain why the gradient (slope) of this graph decreases with time.

....

.... [2]

(ii) Cobalt(II) oxide is a more efficient catalyst for this reaction than copper(II) oxide. Sketch, on the grid, the graph for the reaction catalysed by cobalt(II) oxide. All other conditions were kept constant. [2]

(iii) What can you deduce from the comment that sodium chlorate(I) has to be shielded from light?

....

.... [1]

(iv) Explain, in terms of collisions between particles, why the initial gradient would be steeper if the experiment was repeated at a higher temperature.

....

....

....

.... [3]

(b) The ions present in aqueous sodium chloride are Na^+(aq), Cl^-(aq), H^+(aq) and OH^-(aq).

The electrolysis of concentrated aqueous sodium chloride forms three products. They are hydrogen, chlorine and sodium hydroxide.

(i) Explain how these **three** products are formed. Give ionic equations for the reactions at the electrodes.

....

....

....

....

.... [4]

(ii) If the solution of the electrolyte is stirred, chlorine reacts with sodium hydroxide to form sodium chlorate(I), sodium chloride and water.
Write an equation for this reaction.

Cl_2 + ...NaOH → .... + ... + ...

[2]

[Total: 14]

18. 0620_w14_qp_33 Q: 8

(a) Describe how cobalt chloride paper can be used to test for the presence of water.

....

.... [2]

(b) Complete the description of the preparation of crystals of the soluble salt, cobalt(II) chloride-6-water, $CoCl_2.6H_2O$, from the insoluble base, cobalt(II) carbonate.

$$CoCO_3(s) + 2HCl(aq) \rightarrow CoCl_2(aq) + CO_2(g) + H_2O(l)$$

50 cm^3 of dilute hydrochloric acid, concentration 2.2 mol / dm^3, was heated and cobalt(II)

carbonate was added in small amounts until ....

....

....

....

....

.... [4]

(c) 6.31 g of cobalt(II) chloride-6-water crystals were obtained. Calculate the percentage yield to 1 decimal place.

number of moles of HCl in 50 cm^3 of acid, concentration 2.2 mol / dm^3 = ...

maximum number of moles of $CoCl_2.6H_2O$ which could be formed = ...

mass of 1 mole of $CoCl_2.6H_2O$ = 238 g

maximum yield of $CoCl_2.6H_2O$ = ... g

percentage yield = ...%

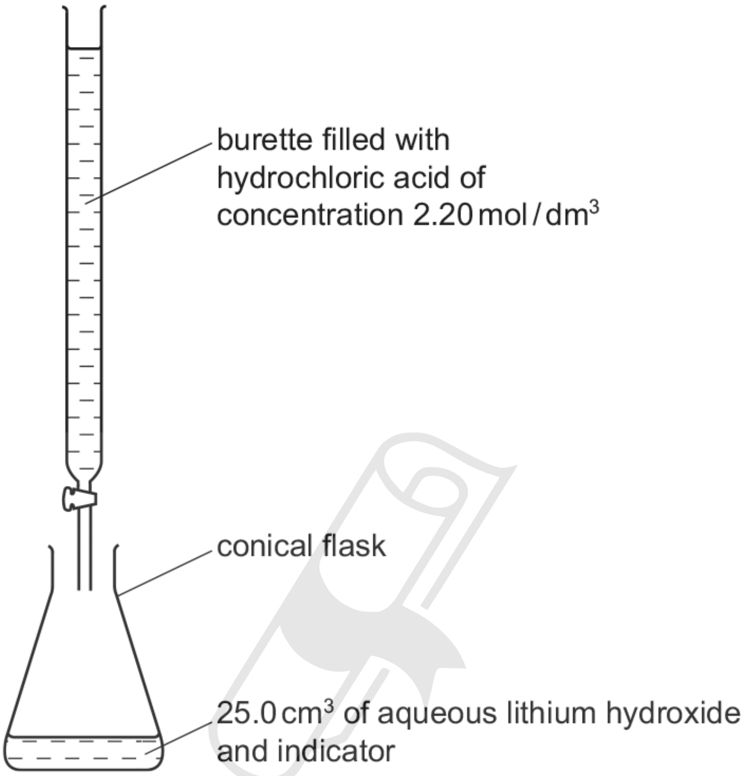
[4]

[Total: 10]

19. 0620_s13_qp_31 Q: 7

The hydroxides of the Group I metals are soluble in water. Most other metal hydroxides are insoluble in water.

(a) **(i)** Crystals of lithium chloride can be prepared from lithium hydroxide by titration.



25.0 cm^3 of aqueous lithium hydroxide is pipetted into the conical flask.
A few drops of an indicator are added. Dilute hydrochloric acid is added slowly to the alkali until the indicator just changes colour. The volume of acid needed to neutralise the lithium hydroxide is noted.

A neutral solution of lithium chloride, which still contains the indicator, is left. Describe how you could obtain a neutral solution of lithium chloride which does **not** contain an indicator.

....

.... [2]

(ii) You cannot prepare a neutral solution of magnesium chloride by the same method. Describe how you could prepare a neutral solution of magnesium chloride.

....

....

.... [3]

(b) The concentration of the hydrochloric acid was 2.20 mol / dm^3. The volume of acid needed to neutralise the 25.0 cm^3 of lithium hydroxide was 20.0 cm^3. Calculate the concentration of the aqueous lithium hydroxide.

$$LiOH + HCl \rightarrow LiCl + H_2O$$

....

....

.... [2]

(c) Lithium chloride forms three hydrates. They are $LiCl.H_2O$, $LiCl.2H_2O$ and $LiCl.3H_2O$. Which **one** of these three hydrates contains 45.9 % of water?
Show how you arrived at your answer.

....

....

.... [3]

[Total: 10]

20. 0620_s12_qp_31 Q: 2

Three ways of making salts are

- titration using a soluble base or carbonate
- neutralisation using an insoluble base or carbonate
- precipitation.

(a) Complete the following table of salt preparations.

method	reagent 1	reagent 2	salt
titration	....	....	sodium nitrate
neutralisation	nitric acid	....	copper(II) nitrate
precipitation	....	....	silver(I) chloride
neutralisation	sulfuric acid	zinc(II) carbonate	....

[6]

(b) **(i)** Write an ionic equation with state symbols for the preparation of silver(I) chloride.

.... [2]

(ii) Complete the following equation.

$ZnCO_3 + H_2SO_4 \rightarrow$ .... + ... + ...

[2]

[Total: 10]

21. 0620_w12_qp_31 Q: 7

Both strontium and sulfur have chlorides of the type XCl_2. The table below compares some of their properties.

	strontium chloride	sulfur chloride
appearance	white crystals	red liquid
formula	$SrCl_2$	SCl_2
melting point / °C	874	–120
boiling point / °C	1250	59
conductivity of liquid	good	poor
solubility in water	dissolves to form a neutral solution	reacts to form a solution of pH 1

(a) **(i)** Use the data in the table to explain why sulfur chloride is a liquid at room temperature, 25 °C.

....

.... [2]

(ii) Strontium is a metal and sulfur is a non-metal. Explain why both have chlorides of the type XCl_2.
The electron distribution of a strontium atom is 2 + 8 + 18 + 8 + 2.

....

....

.... [2]

(iii) Deduce the name of the acidic compound formed when sulfur chloride reacts with water.

.... [1]

(iv) Explain the difference in the electrical conductivity of liquid strontium chloride and liquid sulfur chloride.

....

....

.... [3]

(b) Strontium chloride-6-water can be made from the insoluble compound, strontium carbonate, by the following reactions.

$SrCO_3(s) + 2HCl(aq) \rightarrow SrCl_2(aq) + CO_2(g) + H_2O(l)$

$SrCl_2(aq) + 6H_2O(l) \rightarrow SrCl_2.6H_2O(s)$

The following method was used to prepare the crystals.

1 Add excess strontium carbonate to hot hydrochloric acid.
2 Filter the resulting mixture.
3 Partially evaporate the filtrate and allow to cool.
4 Filter off the crystals of $SrCl_2.6H_2O$.
5 Dry the crystals between filter papers.

(i) How would you know when excess strontium carbonate had been added in step 1?

....

.... [1]

(ii) Why is it necessary to filter the mixture in step 2?

.... [1]

(iii) In step 3, why partially evaporate the filtrate rather than evaporate to dryness?

.... [1]

(c) In the above experiment, 50.0 cm^3 of hydrochloric acid of concentration 2.0 mol/dm^3 was used. 6.4 g of $SrCl_2.6H_2O$ was made.
Calculate the percentage yield.

number of moles of HCl used = ...

number of moles of $SrCl_2.6H_2O$ which could be formed = ...

mass of one mole of $SrCl_2.6H_2O$ is 267 g

theoretical yield of $SrCl_2.6H_2O$ = ...g

percentage yield = ...% [4]

[Total: 15]

01. 0620_m21_ms_42 Q: 4

Question	Answer	Marks
(a)	$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$ $ZnCl_2$ or H_2 as a product (1) correct equation (1) states (1)	**3**
(b)	to make sure all the (hydrochloric) acid reacts	**1**
(c)	filtration	**1**
(d)	a solution that can dissolve no more solute (1) at a given temperature (1)	**2**
(e)	solubility (of $ZnCl_2$ / solids) decreases (as temperature decreases)	**1**
(f)	zinc oxide zinc carbonate	**2**
(g)	Ca will also react with water	**1**
(h)(i)	neutralisation	**1**
(h)(ii)	0.100 × 25 / 1000 = 0.0025(0) (1) 0.0025 × 2 = 0.005(00) (1) 0.005 × 1000 / 20 = 0.25(0) (1) M_r = 40 (1) 0.25 × 40 = 10.(0) (1)	**5**

02. 0620_w21_ms_42 Q: 1

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>(a)</td><td>1 mark for each correct row
<table>
<tr><td>State</td><td>touching</td><td>random movement</td><td>regularly arranged</td></tr>
<tr><td>Gas</td><td></td><td>✓</td><td></td></tr>
<tr><td>Liquid</td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>Solid</td><td>✓</td><td></td><td>✓</td></tr>
</table></td><td>3</td></tr>
<tr><td>(b)(i)</td><td>boiling happens at a specific temperature (1)
boiling has bubbles (1)</td><td>2</td></tr>
<tr><td>(b)(ii)</td><td>condensation (1)
sublimation (1)</td><td>2</td></tr>
<tr><td>(c)</td><td>one horizontal line level with Y (1)
two separate decreases before and after horizontal line (1)</td><td>2</td></tr>
<tr><td>(d)(i)</td><td>dissolving</td><td>1</td></tr>
<tr><td>(d)(ii)</td><td>precipitation</td><td>1</td></tr>
</table>

03. 0620_p20_ms_40 Q: 6

(a) filter / centrifuge / decant; [1]
(partially) evaporate / heat / boil; [1]
allow to crystallise / cool / let crystals form; [1]
dry crystals / dry between filter paper / leave in a warm place to dry; [1]

(b) (i) number of moles of HCl used = 0.04 □ 2 = 0.08; [1]
number of moles $CoCl_2$ formed = 0.04; [1]
number of moles $CoCl_2.6H_2O$ formed = 0.04; [1]
maximum yield of $CoCl_2.6H_2O$ = 9.52; [1]
allow: 9.5
allow: ecf on number of moles of HCl

number of moles of HCl used = 0.08 note: must use their value
allow: ecf
number of moles of $CoCO_3$ in 5.95 g of cobalt(II) carbonate = 5.95/119 = 0.05; [1]

(ii) 0.05 > 0.04 or stated in words;
allow: ecf on number of moles of $CoCl_2$ formed [1]

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04. 0620_w20_ms_42 Q: 2

Question	Answer	Marks
(a)	HNO_3	**1**
(b)(i)	to make sure all the (sulfuric) acid reacts	**1**
(b)(ii)	no (more) fizzing (1) ($FeCO_3$) stops dissolving or a solid remains / is visible (in the mixture) (1)	**2**
(b)(iii)	rinse the residue (with distilled water)	**1**
(b)(iv	a solution that can dissolve no more solute (1) at the specified temperature (1)	**2**
(b)(v)	iron(II) oxide / iron(II) hydroxide	**1**

Question	Answer	Marks
(c)	mass of $FeSO_4$ = 152 (1) mass of H_2O = 278 – 152 = 126 (1) mol of H_2O = 126 / 18 **and** x = 7 (1)	**3**
(d)(i)	precipitation	**1**
(d)(ii)	cream precipitate	**1**
(d)(iii)	$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ AgBr (as only product) (1) Ag^+ and Br^- (as reactants)(1) state symbols(1)	**3**
(e)	M1 mol of NaCl = 2.34 / 58.5 = 0.04(00) M2 mol of Cl_2 = M1/2 = 0.04(00)/2 = 0.02(00) M3 0.02(00) × 24000 = 480 (cm^3)	**3**
(f)(i)	ions (1) (ions) are fixed (in a lattice) (1) ions are mobile (1)	**3**
(f)(ii)	chlorine	**1**
(f)(iii)	oxidation (1) electrons are lost (1)	**2**
(f)(iv)	dissolve it (in water)	**1**

05. 0620_s19_ms_42 Q: 5

(a)	**M1** 0.0025 / 2.5 □ 10^{-3} (moles of H_2SO_4) (1) **M2** 0.0025 / 2.5 □ 10^{-3} (moles of $CuSO_4{\bullet}5H_2O$) (1) **M3** 0.625(g) (1)	**3**
(b)	some copper(II) sulfate remains in solution / some copper(II) sulfate does not form crystals **OR** some of the crystals decomposed **OR** some crystals lost in transfer	**1**
(c)	**M1 no more** bubbling / fizzing / effervescence (1) **M2 solid** or **powder** stops dissolving (1)	**2**
(d)	**M1** (lumps have) smalle**r** surface area **OR powder** has larger surface area (1) **M2** (lumps have) fewer collisions per unit time / less collision frequency **OR powder** has more collisions per unit time / more collision frequency	**2**
(e)	copper(II) oxide **or** copper(II) hydroxide	**1**
(f)	filtration	**1**
(g)(i)	**M1** containing the maximum amount of **dissolved** solute / no more solute can **dissolve** (1) **M2** at any given temperature (1)	**2**
(g)(ii)	when crystals form on a glass rod withdrawn from solution / on a sample of solution placed on microscope slide etc.	**1**
(g)(iii)	(heating to dryness) would remove water **of crystallisation**	**1**

06. 0620_w18_ms_43 Q: 4

(a)	**M1** (Mol KOH =) 0.00125 / 1.25 □ 10^{-3} **M2** (Mol H_2SO_4 =) 0.000625 / 6.25 □ 10^{-4} **M3** (Conc H_2SO_4 =) 0.03125 / 3.125 □ 10^{-2} (mol / dm^3)	**3**

(b)	**SUMMARY** **M1** repeat **M2** heat (liquid or solution should be implied) **M3** when to stop heating **M4** what to do after heating **M5** method of drying crystals (crystals or solid should be implied) **M1** repeat without indicator using same volumes **M2** evaporate / heat / warm / boil / leave in sun **M3** until most of the water is gone / some water left / saturation(point) / crystallisation point / evaporate **some** of the water **M4** leave / (allow to) cool / allow to crystallise **M5** details of drying	**5**
(c)(i)	**M1** bubbles / effervescence / fizzing **M2** solid or magnesium dissolves / solid or magnesium disappears	**2**
(c)(ii)	lilac flame	**1**
(c)(iii)	white precipitate	**1**
(d)(i)	$Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$ **M1** formula of **both** $Mg(OH)_2$ and $MgSO_4$ **M2** equation fully correct	**2**
(d)(ii)	$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ **M1** formula of $ZnSO_4$ **M2** equation fully correct	**2**
(d)(iii)	$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + CO_2 + H_2O$ **M1** formulae of **both** Na_2CO_3 and Na_2SO_4 **M2** equation fully correct	**2**

07. 0620_s17_ms_41 Q: 3

(a)(i)	no (more) effervescence	**1**
(a)(ii)	magnesium carbonate	**1**
(a)(iii)	(a solution in which) no more solute will dissolve	**1**
	at that temperature	**1**
(a)(iv)	the solubility deceases as the temperature decreases	**1**
(b)(i)	moles of water = 2.52 / 18 = 0.14 (mol)	**1**
(b)(ii)	moles of anhydrous magnesium sulfate = 0.02 (mol)	**1**
(b)(iii)	ratio = 0.02 / 0.02 : 0.14 / 0.02 = 1 : 7	**1**

(b)(iv)	$MgSO_4.7H_2O$ **M1** $MgSO_4$ **M2** rest of the formula correct	**2**
(c)	mix and stir the two solutions	**1**
	filter (to obtain residue)	**1**
	wash (the residue) using water	**1**
	dry the residue between filter papers / in a warm place	**1**
(d)	$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$ **M1** correct species **M2** correct state symbols	**2**

08. 0620_p16_ms_40 Q: 6

(a) filter / centrifuge / decant; [1]
(partially) evaporate / heat / boil; [1]
allow to crystallise / cool / let crystals form; [1]
dry crystals / dry between filter paper / leave in a warm place to dry; [1]

(b) **(i)** number of moles of HCl used = 0.04 × 2 = 0.08; [1]
number of moles $CoCl_2$ formed = 0.04; [1]
number of moles $CoCl_2.6H_2O$ formed = 0.04; [1]
maximum yield of $CoCl_2.6H_2O$ = 9.52; [1]
allow: 9.5
allow: ecf on number of moles of HCl

number of moles of HCl used = 0.08 note: must use their value
allow: ecf
number of moles of $CoCO_3$ in 5.95 g of cobalt(II) carbonate = 5.95/119 = 0.05; [1]

(ii) 0.05 > 0.04 or stated in words;
allow: ecf on number of moles of $CoCl_2$ formed [1]

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09. 0620_s16_ms_41 Q: 3

(a)	1 $Na_2S_2O_3$ 2 H_2O 3 HCl **OR** 1 HCl 2 H_2O 3 $Na_2S_2O_3$ **OR** 1 H_2O 2 $Na_2S_2O_3$ 3 HCl **OR** 1 H_2O 2 HCl 3 $Na_2S_2O_3$;	**1**
(b)(i)	**M1** volumes 40 : 10 : 10; **M2** time = 14;	**2** 1 1
(b)(ii)	**M1** more particles per unit volume / particles are closer together; **M2** increases the rate of collisions / there are more collisions per unit time;	**2** 1 1
(c)	**M1** particles gain more energy **and** move faster; **M2** increasing rate of collisions / more collisions per unit time; **M3** higher proportion of particles have sufficient energy to react / collisions have sufficient energy to react / are above the activation energy;	**3** 1 1 1

10. 0620_s16_ms_43 Q: 4

(a)(i)	**M1** movement of electron(s) from potassium to iodine; **M2** one electron transferred;	2 1 1
(a)(ii)	**M1** regular arrangement / (giant) lattice of alternating; **M2** positive potassium ions / K^+ **and** negative iodide ions / I^-;	2 1 1
(a)(iii)	**M1** strong (forces of) attraction (between oppositely charged ions) / ionic bonds are strong; **M2** which require lots of energy to overcome / break;	2 1 1
(b)(i)	**M1** dissolve solids (in water) and mix / combine / add; **M2** filter; **M3** wash the residue (with water); **M4** leave to dry / place in oven / dry between filter papers;	4 1 1 1 1
(b)(ii)	$Pb^{2+} + 2I^- \rightarrow PbI_2$ formulae of ions correct; rest correct;	2
(c)(i)	start colour: colourless; end colour: brown;	2 1 1
(c)(ii)	**M1** iodide / I^-; **M2** it is oxidised **OR** it loses electrons / it increases oxidation number / it reduces the chlorine;	2 1 1

11. 0620_w16_ms_43 Q: 2

(a)	2,2 / 2.2	**1**
(b)	BeO	**1**
(c)(i)	positive ions / cations labelled or named in text electrons labelled or named in text attraction between positive ions and negative electrons	**1** **1** **1**
(c)(ii)	(conduction due to) moving electrons / mobile electrons	**1**
(d)(i)	Be^{2+}	**1**
(d)(ii)	$Be(OH)_2 + 2HCl \rightarrow BeCl_2 + 2H_2O$ formula of $BeCl_2$ all formulae correct and balancing correct	**2**
(d)(iii)	$2NaOH + Be(OH)_2 \rightarrow Na_2BeO_2 + 2H_2O$ formula of Na_2BeO_2 all formulae correct and balancing correct	**2**

12. 0620_s15_ms_31 Q: 6

(a)(i)	M1 proton acceptor; M2 does not accept (protons) readily **OR** less able to accept protons (than strong bases);	2	**A** alternative words to 'acceptor' e.g. 'receiver' **I** references to pH **A** 'hydrogen ion' or 'H^+' for proton **I** accepts fewer / less protons
(a)(ii)	M1 same concentration of both bases; M2 measure their pH; M3 the higher pH is the stronger base;	3	**A** suitable method e.g. universal indicator or pH paper or pH meter **I** litmus or methyl orange or phenolphthalein **I** titration methods for M2 and M3 **A** suitable colours of both weak strong bases e.g. ethylamine is (greeny)blue, NaOH is dark**er** blue / purple **A** alternative methods for M2 and M3 e.g. measure conductivity (M2) and higher conductivity is the stronger base (M3) e.g.add aluminium / Al (M2) and stronger base gives faster rate of effervescence / more fizzing / more bubbling (M3)
(b)(i)	$2CH_3CH_2NH_2 + H_2SO_4 \rightarrow (CH_3CH_2NH_3)_2SO_4$ species; balancing; the salt is ethylammonium sulfate;	3	**A** multiples **I** state symbols **A** one mark for correct product **A** close spellings **A** diethylammonium sulfate
(b)(ii)	sodium hydroxide / calcium hydroxide / NaOH / $Ca(OH)_2$;	1	**A** any Group 1 or Group 2 hydroxide or oxide
(c)(i)	*Any **two** from:* (particles move in) random motion; (particles) collide; (particles) move from a region of high concentration to low concentration;	2	**A** alternative phrases for collide **A** down a concentration gradient
(c)(ii)	C; M2 it has a lower (relative) molecular mass (than HBr); M3 ethylamine diffuses faster (than HBr);	3	**A** ethylamine is less dense **A** ethylamine is a lighter molecule but **I** 'ethylamine is lighter' **I** ethylamine is a smaller molecule **A** ethylamine **molecules** or **particles** move faster **A** ECF for M2 and M3 if A is given e.g. HBr diffuses faster for M3 because it is a lighter molecule for M2 **A** ECF for M2 if B is given e.g. they diffuse at same rate for M3 because molecules weigh the same for M2

13. 0620_s15_ms_32 Q: 5

(a)	method A; hydrochloric acid / $\mathrm{HC}l$ / hydrogen chloride solution; nickel carbonate + hydrochloric acid → nickel chloride + water + carbon dioxide;	3	hydrochloric acid / $\mathrm{HC}l$ can only score if written in the reagent space i.e. **R** hydrochloric acid / $\mathrm{HC}l$ in equation if reagent space is blank **I** hydrogen chloride (therefore 'hydrogen chloride + $\mathrm{HC}l$' would get mark 2 BOD) **I** nickel carbonate **A** fully correct balanced chemical equation i.e. $\mathrm{NiCO_3} + 2\mathrm{HC}l \rightarrow \mathrm{NiC}l_2 + \mathrm{CO_2} + \mathrm{H_2O}$ for the third mark **R** combination of words and formulae in the same equation for the third mark **I** concentration of acid for marks 2 and 3
(b)	method C; any (aqueous / dilute / solution of soluble) bromide including potassium bromide / KBr, hydrogen bromide / HBr i.e. all bromides except silver, lead and mercury; $\mathrm{Pb^{2+}} + 2\mathrm{Br^-} \rightarrow \mathrm{PbBr_2}$;	3	**A correct** formula of soluble bromide **I** lead nitrate **I** state symbols **A** multiples
(c)	method B; sulfuric acid / hydrogen sulfate / $\mathrm{H_2SO_4}$; $2\mathrm{LiOH} + \mathrm{H_2SO_4} \rightarrow \mathrm{Li_2SO_4} + 2\mathrm{H_2O}$ species; balancing;	4	**I** concentration of acid for mark 2 **I** indicators / lithium hydroxide **I** state symbols **A** multiples

14. 0620_w15_ms_33 Q: 7

(a)	*moles of KOH used* (= 0.025 × 2.53 =) 0.06325 / 0.063; *number of moles of H_2SO_4 needed to neutralise the KOH* = 0.031625 / 0.032; *concentration of dilute sulfuric acid* = 1.121/1.1 (mol / $\mathrm{dm^3}$);	3
(b)(i)	repeat experiment using same volume / amount of (same) $\mathrm{H_2SO_4}$; and same volume / amount of (same) KOH; **or** (add activated) charcoal / carbon; filter out the charcoal; **or** mix volumes / amounts of $\mathrm{H_2SO_4}$ and KOH in the ratio 1:2; of the same concentration;	2
(b)(ii)	make solution of potassium sulfate as above; add same volume / amount of acid again; **or** same volume / amount of KOH; add double the volume / amount of $\mathrm{H_2SO_4}$; 25 $\mathrm{cm^3}$ KOH + 56.4 $\mathrm{cm^3}$ $\mathrm{H_2SO_4}$ = [2] **or** same volume / amount of $\mathrm{H_2SO_4}$; add half the volume / amount of KOH; 12.5 $\mathrm{cm^3}$ KOH + 28.2 $\mathrm{cm^3}$ $\mathrm{H_2SO_4}$ = [2] **or** mix equal volumes / amounts of $\mathrm{H_2SO_4}$ and KOH ; of the same concentration; mix solutions containing equal numbers moles of KOH and $\mathrm{H_2SO_4}$ = [2]	2

(c)	*test:* reactive metal / name or formula of suitable metal, e.g. Mg / Fe / Zn; *result:* bubbles or gas or hydrogen or H_2 evolved / dissolves; *test:* insoluble carbonate or name / formula of suitable insoluble carbonate, e.g. $CaCO_3$; *result:* bubbles or gas or carbon dioxide or CO_2 evolved / dissolves provided that carbonate is insoluble; *test:* alkali or name / formula of suitable alkali, e.g. NaOH / KOH; *result:* temperature change; *test:* alkali or name / formula of suitable alkali, e.g. NaOH / KOH and indicator; *result:* colour change; *test:* insoluble base or name / formula of suitable insoluble base; *result:* dissolves; *test:* indicator, e.g. blue litmus; *result:* colour change (colour need not be specified); *test:* measure pH / pH paper / UI paper / pH meter; *result:* pH 0–3 or indicator red / orange or pH lower than pH of K_2SO_4;	**2**

15. 0620_s14_ms_32 Q: 7

(a) repeat without indicator **/** repeat using same volumes of acid and alkali **or** use carbon / charcoal to remove indicator (1)

evaporate / heat / warm / boil / leave in sun (1)

until most of the water has gone / some water is left / saturation (point) / crystallisation point (1)

leave / allow to cool / allow to crystallise (1)

filter (off crystals) / wash(with distilled water) / dry crystals with filter paper / dry crystals in warm place / oven / windowsill (1) [5]

(b) <u>0.062</u> (1)

0.031 (1)

3.97 g (1)

55.4% (1) [4]

(c) **(i)** (to prove) <u>**all**</u> water driven off or evaporated or boiled / no water remains / to make salt anhydrous (1)

(ii) $m_1 - m_2$ = mass of water (1)

(calculate) <u>moles of water</u> **AND** moles of hydrated or anhydrous salt (1)

1:1 ratio / should be equal (1) [3]

16. 0620_w14_ms_32 Q: 1

(a) foodstuffs or drugs [1]

(b) **(i)** simple distillation
fractional distillation **or** diffusion
fractional distillation
filtration **or** evaporation
chromatography [5]

(ii) M1 dissolving
M2 filtration
M3 evaporation or heat (to crystallisation point)
M4 crystallisation or allow leave to cool [4]
or
M3 crystallisation
M4 filtration

OR: Adding to H_2SO_4 method

M1 Add excess mixture to acid (or until no more dissolves)
M2 Filtration
or
M1 Add excess acid to mixture
M2 With heat

M3 evaporation or heat (to crystallisation point) Stop marking if heated to dryness.
M4 crystallisation or allow leave to cool
or
M3 crystallisation
M4 filtration

[Total: 10]

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17. 0620_w14_ms_33 Q: 5

(a) (i) rate decreases [1]
concentration of sodium chlorate ((I))/reactant decreases [1]

(ii) (initial) gradient greater/steeper (must start at origin) [1]
same final volume of oxygen [1]

(iii) (to prevent)photochemical reaction/(to prevent)reaction catalysed by light/light breaks down or decomposes sodium chlorate((I)) [1]

(iv) particles have more energy/particles move faster/ [1]
more collisions [1]
collisions more frequent or more often/greater chance of collision/collision rate increases/more particles have energy to react/more collisions are successful or effective [1]

(b) (i) $2Cl^- \rightarrow Cl_2 + 2e(^-)$ / $2Cl^- - 2e(^-) \rightarrow Cl_2$ [1]

$2H^+ + 2e(^-) \rightarrow H_2$ / $2H^+ \rightarrow H_2 - 2e(^-)$ [1]

hydrogen formed at cathode/– and chlorine at anode/+ [1]

Na^+ and OH^- **or** sodium ions and hydroxide ions left in solution/form/become sodium hydroxide [1]

(ii) $Cl_2 + 2NaOH \rightarrow NaClO/NaOCl + NaCl + H_2O$ [2]
Species (1) Balancing (1)

[Total: 14]

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18. 0620_w14_ms_33 Q: 8

(a) (changes from) blue (1) to pink (1) [2]

(b) no more (solid) dissolves **or** no more cobalt(II) carbonate dissolves **or** no more effervescence **or** bubbling **or** fizzing [1]

filter(residue)/centrifuge/decant [1]

evaporate/heat/warm/boil/leave in sun **AND** until most of the water has gone/some water is left/until it is concentrated/saturation (point)/crystallisation point/crystals form on glass rod or microscope slide/crystals start to form [1]

Leave/allow to cool/allow to crystallise/filter (off crystals)/wash(with distilled water)/dry crystals with filter paper/dry crystals in warm place **or** dry in oven **or** dry on windowsill [1]

(c) number of moles of $\mathrm{HC}l$ in 50 cm^3 of acid, concentration 2.2 $\mathrm{mol/dm}^3$ = 0.11 [1]

maximum number of moles of $\mathrm{CoC}l_2.6\mathrm{H}_2\mathrm{O}$ which could be formed = 0.055 [1]

mass of 1 mole of $\mathrm{CoC}l_2.6\mathrm{H}_2\mathrm{O}$ = 238 g

maximum yield of $\mathrm{CoC}l_2.6\mathrm{H}_2\mathrm{O}$ = 13.09 g [1]

percentage yield = 48.2% **or** ecf mass of $\mathrm{CoC}l_2.6\mathrm{H}_2\mathrm{O}$ above/13.09 × 100% to 1 dp [1]

[Total: 10]

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19. 0620_s13_ms_31 Q: 7

(a) **(i)** add carbon / animal charcoal [1]
filter [1]

OR

repeat experiment without indicator [1]
using same quantity / volume of acid [1]

(ii) add magnesium metal / carbonate / oxide / hydroxide
to (hot) (hydrochloric) acid [1]

cond: until in excess **or** no more dissolves **or** reacts [1]

cond: filter (to remove unreacted solid) [1]

(b) number of moles of HC*l* = 0.020 x 2.20 = 0.044 [1]
number of moles of LiOH = 0.044
concentration of LiOH = 0.044/0.025 = 1.769 (mol / dm^3) [1]
accept 1.75 to 1.77 need 2 dp
correct answer scores = 2

(c) (for $LiCl.2H_2O$)
mass of one mole = 78.5 [1]
percentage water = 36 / 78.5 x 100 [1]
45.9 so is $LiCl.2H_2O$ [1]
only award the marks if you can follow the reasoning and it gives 45.9% of water

note: if correct option given mark this and ignore the rest of the response

allow: max 2 for applying a correct method to another hydrate, [1] for the method and [1] for the correct value, working essential

[Total: 10]

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20. 0620_s12_ms_31 Q: 2

(a) nitric acid; [1]
sodium hydroxide / carbonate / hydrogen carbonate; [1]

copper(II) oxide / hydroxide / carbonate; [1]

any named soluble chloride; [1]
accept: *hydrochloric acid / hydrogen chloride*
silver(I) nitrate / ethanoate / sulfate; [1]
must be soluble silver salt **not** *silver oxide / carbonate*

zinc(II) sulfate [1]

(b) (i) $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ [2]
equation correct state symbols missing [1]

(ii) $ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + CO_2 + H_2O$ [2]
correct formula for zinc sulfate = 1

[Total: 10]

21. 0620_w12_ms_31 Q: 7

(a) (i) melting point is below 25°C; [1]
boiling point above 25°C; [1]
accept: argument based on actual values
note: 25°C is between mp and bp = [2]

(ii) strontium loses 2e; [1]
sulfur gains 2e; [1]

(iii) hydrogen chloride / hydrochloric acid; [1]
accept: sulfurous acid or sulfur dioxide

(iv) molten strontium chloride has ions / ionic compound; [1]
which can move; [1]
sulfur chloride has no ions / only molecules / molecular / covalent; [1]

(b) (i) strontium carbonate does not dissolve / no effervescence; [1]
note: not just reaction is complete

(ii) to remove excess / unreacted / undissolved <u>strontium carbonate;</u> [1]

(iii) water of crystallisation needed / $6H_2O$ in crystals / would get anhydrous salt / would not get hydrated salt / crystals dehydrate; [1]
not: just to obtain crystals

(c) number of moles of HCl used = 0.05 × 2 = 0.1 [1]
number of moles of $SrCl_2.6\ H_2O$ which could be formed. = 0.05 [1]
mass of one mole of $SrCl_2.6H_2O$ is 267 g
theoretical yield of $SrCl_2.6H_2O$ = 0.05 × 267 = 13.35 g [1]
percentage yield = 6.4 / 13.35 × 100 = 47.9% [1]
accept: 48%
allow: ecf

[Total: 15]