

1 Silicon(IV) oxide, SiO_2 , and zirconium(IV) oxide, ZrO_2 , are both macromolecules. They have similar physical properties but silicon(IV) oxide is acidic and zirconium(IV) oxide is amphoteric.

(a) Define the term *macromolecule*.

.....
..... [1]

(b) (i) Predict **three** physical properties of these two oxides.

.....
.....
..... [3]

(ii) Name an element which has the same physical properties as these two oxides.

..... [1]

(c) (i) Name a reagent that reacts with the oxides of both elements.

..... [1]

(ii) Name a reagent that reacts with only one of the oxides.

reagent

oxide which reacts [2]

[Total: 8]

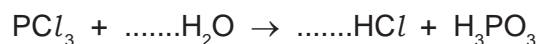
2 Chlorine reacts with phosphorus to form phosphorus trichloride.

- (a) Draw a diagram showing the arrangement of the **valency** electrons in one molecule of the covalent compound, phosphorus trichloride.
Use x to represent an electron from a phosphorus atom.
Use o to represent an electron from a chlorine atom.

[2]

(b) Phosphorus trichloride reacts with water to form two acids.

- (i) Balance the equation for this reaction.



[1]

- (ii) Describe how you could show that phosphorus acid, H_3PO_3 , is a weaker acid than hydrochloric acid.

.....
.....
..... [3]

- (iii) Two salts of phosphorus acid are its sodium salt, which is soluble in water, and its calcium salt which is insoluble in water. Suggest a method of preparation for each of these salts from aqueous phosphorus acid. Specify any other reagent needed and briefly outline the method.

sodium salt

.....

.....

..... [2]

calcium salt

.....

.....

..... [2]

[Total: 10]

3 This question is concerned with the following oxides.

- sulfur dioxide
- carbon monoxide
- lithium oxide
- aluminium oxide
- nitrogen dioxide
- strontium oxide

(a) Which of the above oxides will react with hydrochloric acid but not with aqueous sodium hydroxide?

..... [1]

(ii) Which of the above oxides will react with aqueous sodium hydroxide but not with hydrochloric acid?

..... [1]

(iii) Which of the above oxides will react with both hydrochloric acid and aqueous sodium hydroxide?

..... [1]

(iv) Which of the above oxides will not react with hydrochloric acid or with aqueous sodium hydroxide?

..... [1]

(b) Two of the oxides are responsible for acid rain.
Identify the **two** oxides and explain their presence in the atmosphere.

.....
.....
.....
.....
..... [5]

(c) Lithium oxide is an ionic compound.

(i) Identify another ionic oxide in the list on page 3.

..... [1]

(ii) Draw a diagram which shows the formula of lithium oxide, the charges on the ions and the arrangement of the valency electrons around the negative ion.
Use x to represent an electron from an atom of oxygen.
Use o to represent an electron from an atom of lithium.

[2]

[Total: 12]

4 Soluble salts can be made by the neutralisation of an acid by a base. Insoluble salts can be made by precipitation.

(a) The following is a brief description of the preparation of the soluble salt, nickel(II) chloride-6-water, from the insoluble base nickel(II) carbonate.

Nickel(II) carbonate is added in small amounts to hot dilute hydrochloric acid until it is in excess. The mixture is filtered. The filtrate is partially evaporated and then allowed to cool until crystals of nickel(II) chloride-6-water form.

(i) Why is it necessary to use excess carbonate?

.....
..... [1]

(ii) Explain why it is necessary to filter.

..... [1]

(iii) Why partially evaporate rather than evaporate to dryness?

.....
..... [1]

(iv) What additional steps are needed to obtain dry crystals?

.....
..... [2]

(b) Potassium chloride can be made from hydrochloric acid and potassium carbonate.

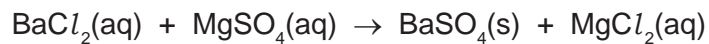
(i) Why must a different experimental method be used for this preparation?

.....
..... [1]

(ii) Give a description of the different method used for this salt preparation.

.....
.....
.....
..... [4]

- (c) Insoluble salts are made by precipitation. An equation for the preparation of barium sulfate is given below.



This reaction can be used to find x in the formula for hydrated magnesium sulfate $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$.

A known mass of hydrated magnesium sulfate, $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$, was dissolved in water. Excess aqueous barium chloride was added. The precipitate of barium sulfate was filtered, washed and dried. Finally it was weighed.

Mass of hydrated magnesium sulfate = 1.476 g

Mass of barium sulfate formed = 1.398 g

The mass of one mole of BaSO_4 = 233 g

The number of moles of BaSO_4 formed = [1]

The number of moles of $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ = [1]

The mass of one mole of $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ = g [1]

The mass of one mole of MgSO_4 = 120 g

The mass of $x\text{H}_2\text{O}$ in one mole of $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ = [1]

x = [1]

[Total: 15]

5 Thallium is a metal in Group III. It has oxidation states of +1 and +3.

(a) Give the formula for the following thallium compounds.

(i) thallium(I) sulfide [1]

(ii) thallium(III) chloride [1]

(b) Thallium(I) chloride is insoluble in water. Complete the description of the preparation of a pure sample of this salt.

Step 1

Mix a solution of sodium chloride with thallium(I) sulfate solution. A white precipitate forms.

Step 2

..... [1]

Step 3

..... [1]

Step 4

..... [1]

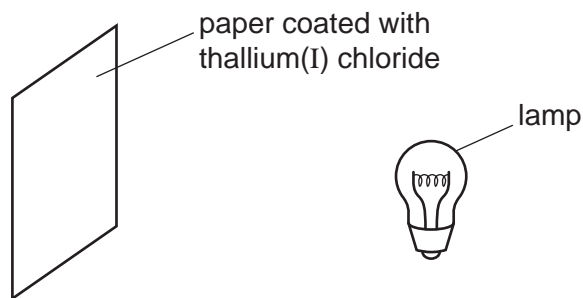
(c) When thallium(I) chloride is exposed to light, a photochemical reaction occurs. It changes from a white solid to a violet solid.

(i) Name another metal halide which changes colour when exposed to light. Give the major use of this metal halide.

name

use [2]

(ii) A piece of paper coated with thallium(I) chloride is exposed to a bright light.



Suggest **two** ways of increasing the time it takes for the violet colour to appear.

.....

 [2]

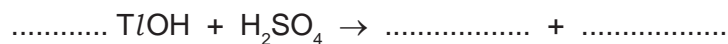
(d) Thallium(I) hydroxide is an alkali. It has similar properties to sodium hydroxide.

(i) Complete the following word equation.



[1]

(ii) Complete the equation.



[2]

(iii) Aqueous thallium(I) hydroxide was added to aqueous iron(II) sulfate. Describe what you would see and complete the ionic equation for the reaction.

observation

..... [1]



[1]

[Total: 14]

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

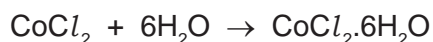
.....
.....

Step 4

.....
.....

[4]

- (b) 6.0 g of cobalt(II) carbonate was added to 40 cm³ of hydrochloric acid, concentration 2.0 mol/dm³. Calculate the maximum yield of cobalt(II) chloride-6-water and show that the cobalt(II) carbonate was in excess.



Maximum yield

Number of moles of HCl used =

Number of moles of CoCl₂ formed =

Number of moles of CoCl₂·6H₂O formed =

Mass of one mole of CoCl₂·6H₂O = 238 g

Maximum yield of CoCl₂·6H₂O = g [4]

To show that cobalt(II) carbonate is in excess

Number of moles of HCl used = (use value from above)

Mass of one mole of CoCO₃ = 119 g

Number of moles of CoCO₃ in 6.0 g of cobalt(II) carbonate = [1]

Explain why cobalt(II) carbonate is in excess

..... [1]

[Total: 10]