Acid, Bases and Salts

(Past Year Topical Questions 2010-2015)

May/June 2010 (32)/Q6

(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]

Oct/Nov 2010 (31)

8 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]

Oct/Nov 2010 (33)/Q2

(ii) Vanadium(III) oxide is basic and vandium(IV) oxide is amphoteric.
Describe how you would obtain a sample of vanadium(III) oxide from a mixture of these two oxides.

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.....

..... [3]

May/June 2011 (32)/Q7

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

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..... [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]

Oct/Nov 2011 (31)

1 This question is concerned with the following oxides.

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

(a) (i) 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.

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.....

.....

..... [5]

Oct/Nov 2011 (32)

6 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]

May/June 2012 (31)

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]

May/June 2012 (32)

8 Ethylamine, $CH_3–CH_2–NH_2$, is a base which has similar properties to ammonia.

(a) In aqueous ethylamine, there is the following equilibrium.

$$CH_3–CH_2–NH_2 + H_2O \rightleftharpoons CH_3–CH_2–NH_3^+ + OH^-$$

Explain why water is behaving as an acid in this reaction.

..... [1]

(b) Given aqueous solutions of ethylamine and sodium hydroxide, describe how you could show that ethylamine is a weak base like ammonia and not a strong base like sodium hydroxide.

.....

.....

..... [3]

(c) Ethylamine, like ammonia, reacts with acids to form salts.

$$CH_3–CH_2–NH_2 + HCl \rightarrow CH_3–CH_2–NH_3Cl$$

ethylammonium chloride

Suggest how you could displace ethylamine from the salt, ethylammonium chloride.

.....

..... [2]

(d) Explain the chemistry of the following reaction:

When aqueous ethylamine is added to aqueous iron(III) chloride, a brown precipitate is formed.

.....

..... [2]

[Total: 8]

Oct/Nov 2012 (31)

(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]

Oct/Nov 2012 (33)/Q4

(iii) This impure solution of zinc sulfate contains zinc ions, silver(I) ions and lead ions. Explain why the addition of zinc powder produces pure zinc sulfate solution. Include at least one ionic equation in your explanation.

.....

.....

.....

.....

..... [4]

May/June 2013 (31)

(e) The hydroxide of **M** is a white powder which is insoluble in water. Describe how you could show that this hydroxide is amphoteric.

.....

.....

..... [2]

May/June 2013 (33)/Q6

(b) (i) Suggest why a solution of malonic acid, concentration 0.2 mol / dm^3, has a higher pH than one of sulfuric acid of the same concentration.

..... [1]

(ii) Describe a test, other than measuring pH, which can be carried out on both acid solutions to confirm the explanation given in **(b)(i)** for the different pH values of the two acids.

.....

..... [2]

+6018 – 375 2833

Oct/Nov 2013 (32)

5 Silver(I) chromate(VI) is an insoluble salt. It is prepared by precipitation.
20 cm^3 of aqueous silver(I) nitrate, concentration 0.2 mol/dm^3, was mixed with 20 cm^3 of aqueous potassium chromate(VI), concentration 0.1 mol/dm^3. After stirring, the mixture was filtered. The precipitate was washed several times with distilled water. The precipitate was then left in a warm oven for several hours.

$$2AgNO_3(aq) + K_2CrO_4(aq) \rightarrow Ag_2CrO_4(s) + 2KNO_3(aq)$$

(a) What difficulty arises if the name of a compound of a transition element does not include its oxidation state, for example iron oxide?

.....

..... [2]

(b) These questions refer to the preparation of the salt.

(i) Why is it necessary to filter the mixture after mixing and stirring?

..... [1]

(ii) What is the purpose of washing the precipitate?

..... [1]

(iii) Why leave the precipitate in a warm oven?

..... [1]

(c) **(i)** Explain why the concentrations of silver(I) nitrate and potassium chromate(VI) are different.

..... [1]

May/June 2014 (32) /Q6

(c) Scandium oxide is insoluble in water. Describe how you could show that it is an amphoteric oxide.

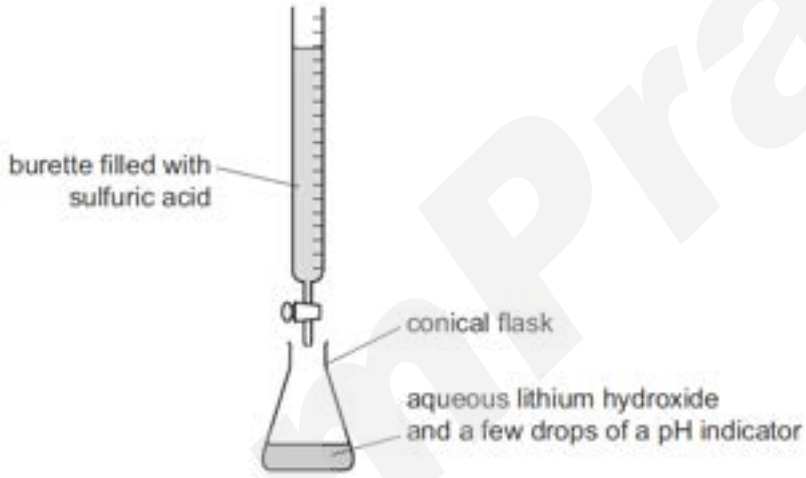
.....

.....

.....

..... [3]

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.

.....

.....

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.....

.....

..... [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]

Oct/Nov 2014 (31)

1 (a) Match the following pH values to the solutions given below.

1 3 7 10 13

The solutions all have the same concentration.

solution	pH
aqueous ammonia, a weak base	.....
dilute hydrochloric acid, a strong acid	.....
aqueous sodium hydroxide, a strong base	.....
aqueous sodium chloride, a salt	.....
dilute ethanoic acid, a weak acid	.....

[5]

(b) Explain why solutions of hydrochloric acid and ethanoic acid with the same concentration, in mol/dm^3, have a different pH.

.....

.....

..... [2]

(c) Measuring pH is one way of distinguishing between a strong acid and a weak acid. Describe another method.

method .....

.....

results .....

.....

[2]

[Total: 9]

May/June 2015 (31)

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.

.....$CH_3CH_2NH_2$ + ... → .....

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]

May/June 2015 (32)

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]

May/June 2015 (33)

2 This question is concerned with the following oxides.

aluminium oxide
carbon monoxide
copper(II) oxide
silicon(IV) oxide
sodium oxide
sulfur dioxide
zinc oxide

Choose **one** oxide from the above list to match each of the following descriptions. An oxide may be used once, more than once or not at all.

(a) This oxide does not react with acid or alkali. ..... [1]

(b) This oxide reacts with water to give a strong alkali solution. ..... [1]

(c) This oxide is used as a bleach. ..... [1]

(d) This oxide is amphoteric. ..... [1]

(e) This oxide has a giant covalent structure. ..... [1]

(f) This oxide is soluble in water and it is acidic. ..... [1]

[Total: 6]

Oct/Nov 2015 (31)

6 Carbon and silicon are elements in Group IV. They both form oxides of the type XO_2.

(a) Silicon(IV) oxide, SiO_2, has a macromolecular structure.

(iii) How could you show that silicon(IV) oxide is acidic and not basic or amphoteric?

.....

.....

..... [2]

Oct/Nov 2015 (32)

6 The table below shows the elements in the third period of the Periodic Table, the number of electrons in their outer energy level, their oxidation state in their common compounds and their melting points.

element	Na	Mg	Al	Si	P	S	Cl	Ar
number of outer electrons	1	2	3	4	5	6	7	8
oxidation state	+1	+2	+3	+4/–4	–3	–2	–1	0
melting point/°C	98	650	660	1414	317	115	–101	–189

(g) Describe how you could show that magnesium oxide is a basic oxide and not an amphoteric oxide.

.....

..... [2]

Oct/Nov 2015 (33)

5 Sulfuric acid is a strong acid. In aqueous solution, it ionises as shown below.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

(a) (i) What is meant by the term *acid*?

..... [1]

(ii) Sulfurous acid, H_2SO_3, is a weak acid.

State the difference between a weak acid and a strong acid.

.....

..... [2]

(b) Sulfurous acid forms salts called sulfites, which contain the ion SO_3^{2-}.

When barium nitrate solution is added to aqueous sulfurous acid, a white precipitate, **A**, forms.

Bromine water changes from brown to colourless when added to aqueous sulfurous acid.

Bromine oxidises sulfurous acid. When this solution is tested with acidified barium nitrate solution, a different white precipitate, **B**, is formed.

(i) Identify the white precipitate, **A**.

..... [1]

(ii) Identify the white precipitate, **B**.

..... [1]

(iii) Write an ionic equation for the reduction of the bromine molecule.

..... [1]

(iv) Name the product formed by the oxidation of sulfurous acid.

..... [1]

(c) Complete the following word equations.

(i) magnesium hydroxide + dilute sulfuric acid

..... [1]

(ii) zinc + dilute sulfuric acid

..... [1]

(iii) copper carbonate + dilute sulfuric acid

..... [1]

(d) Write equations for the reaction of dilute sulfuric acid with each of the following.

(i) ammonia

..... [2]

(ii) sodium hydroxide

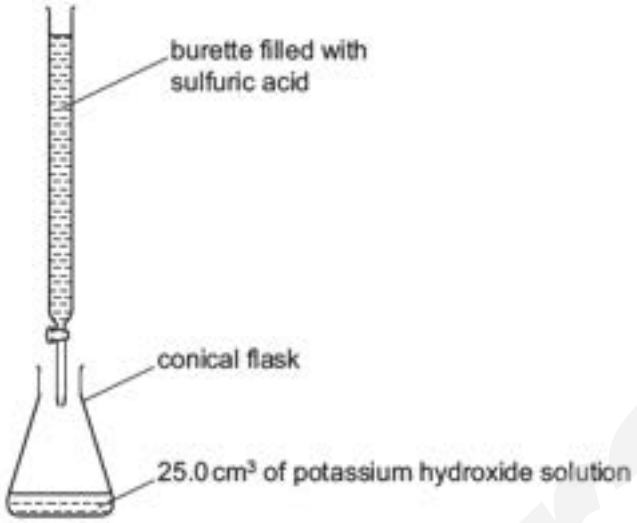
..... [2]

(iii) iron

..... [2]

[Total: 16]

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.



(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]