F321: Atoms, Bonds and Groups
Acids

49 Marks

1. A student carries out experiments using acids, bases and salts.

Calcium nitrate, $Ca(NO_3)_2$, is an example of a salt.

The student prepares a solution of calcium nitrate by reacting dilute nitric acid, HNO_3, with the base calcium hydroxide, $Ca(OH)_2$.

(i) Why is calcium nitrate an example of a salt?

.....

.....

[1]

(ii) Write the equation for the reaction between dilute nitric acid and calcium hydroxide. Include state symbols.

.....

[2]

(iii) Explain how the hydroxide ion in aqueous calcium hydroxide acts as a base when it neutralises dilute nitric acid.

.....

.....

.....

[1]

[Total 4 marks]

2. (a) A student carries out a titration to find the concentration of some sulfuric acid.

The student finds that 25.00 cm^3 of 0.0880 mol dm^{-3} aqueous sodium hydroxide, NaOH, is neutralised by 17.60 cm^3 of dilute sulfuric acid, H_2SO_4.

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

(i) Calculate the amount, in moles, of NaOH used.

answer = ... mol

[1]

(ii) Determine the amount, in moles, of H_2SO_4 used.

answer = ... mol

[1]

(iii) Calculate the concentration, in mol dm^{-3}, of the sulfuric acid.

answer = ... mol dm^{-3}

[1]

(b) After carrying out the titration in (a), the student left the resulting solution to crystallise. White crystals were formed, with a formula of $Na_2SO_4 \bullet \boldsymbol{x}\ H_2O$ and a molar mass of 322.1 g mol^{-1}.

(i) What term is given to the '$\bullet \boldsymbol{x}\ H_2O$' part of the formula?

.....

[1]

(ii) Using the molar mass of the crystals, calculate the value of ***x***.

answer = ...

[2]

[Total 6 marks]

3. Ammonium compounds such as ammonium sulfate, $(NH_4)_2SO_4$, can be used as fertilisers.

(i) Write a balanced equation to show how ammonium sulfate could be formed by the reaction between aqueous ammonia and sulfuric acid.

.....

[1]

(ii) Ammonium sulfate is an example of a salt formed when an acid is neutralised by a base.

Explain what is meant by the term *salt*.

.....

.....

[1]

(iii) Why is ammonia acting as a base in this neutralisation?

.....

.....

[1]

(iv) What is the relative formula mass of $(NH_4)_2SO_4$?

Give your answer to **one** decimal place.

.....

[1]

[Total 4 marks]

4. Epsom salts can be used as bath salts to help relieve aches and pains.

Epsom salts are crystals of hydrated magnesium sulfate, $MgSO_4 \bullet \boldsymbol{x} H_2O$.

A sample of Epsom salts was heated to remove the water. 1.57 g of water was removed leaving behind 1.51 g of anhydrous $MgSO_4$.

(i) Calculate the amount, in mol, of anhydrous $MgSO_4$ formed.

amount = ... mol

[2]

(ii) Calculate the amount, in mol, of H_2O removed.

amount = ... mol

[1]

(iii) Calculate the value of ***x*** in $MgSO_4 \cdot xH_2O$.

x = ...

[1]

[Total 4 marks]

5. Calcium oxide reacts with water and with nitric acid.

State the formula of the calcium compound formed when:

(i) calcium oxide reacts with water, ...

[1]

(ii) calcium oxide reacts with nitric acid. .....

[1]

[Total 2 marks]

6. Calcium and its compounds, have properties typical of Group 2 in the Periodic Table.

Calcium carbonate, $CaCO_3$, reacts with acids such as nitric acid.

A student neutralised 2.68 g of $CaCO_3$ with 2.50 mol dm^{-3} nitric acid, HNO_3.

The equation for this reaction is shown below.

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

(i) Determine the amount, in mol, of $CaCO_3$ reacted.

amount = ... mol

[2]

(ii) Calculate the volume, in cm^3, of CO_2 produced at room temperature and pressure.

volume = ... cm_3

[1]

(iii) Calculate the volume of 2.50 mol dm^{-3} HNO_3 needed to neutralise 2.68 g of $CaCO_3$.

volume = ... cm^3

[2]

[Total 5 marks]

7. Old samples of magnesium oxide become contaminated with magnesium carbonate.

(i) Suggest how this contamination takes place.

.....

.....

[1]

(ii) A student added an excess of hydrochloric acid to an old sample of magnesium oxide that is contaminated with magnesium carbonate.

State **two** observations that the student would make.

.....

.....

[2]

(iii) Explain, with the aid of equations, why the resulting solution contained only one dissolved compound of magnesium.

.....

.....

.....

.....

.....

[3]

[Total 6 marks]

8. Both calcium carbonate, $CaCO_3$, and calcium oxide, CaO, are white solids.

Dilute hydrochloric acid, HC*l*, can be used to identify whether a sample of white solid is $CaCO_3$ or CaO.

(i) Write equations, including state symbols, for the reaction of HC*l* with $CaCO_3$ and the reaction of HC*l* with CaO.

.....

.....

[3]

(ii) How would observation of the reactions with hydrochloric acid allow the identification of the white solid?

$CaCO_3$ .....

.....

CaO .....

.....

[1]

[Total 4 marks]

9. A small amount of solid magnesium oxide, MgO, was reacted with excess dilute hydrochloric acid.

(i) Define an acid.

.....

[1]

(ii) Write a balanced equation for this reaction.

.....

[1]

[Total 2 marks]

10. Chewing chalk has been used for many years to combat excess stomach acid and indigestion tablets often contain calcium carbonate, $CaCO_3$. Suggest, with the aid of an equation, how these tablets work.

.....

.....

.....

[Total 2 marks]

11. Ammonia reacts with sulphuric acid, as shown in the equation below.

$$2NH_3(g) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

(i) Complete the statement below to describe how ammonia is behaving in this reaction.

Ammonia is behaving as a ..... because

.....

[2]

(ii) State **one** important use for the compound $(NH_4)_2SO_4$.

.....

[1]

(iii) Apart from the manufacture of $(NH_4)_2SO_4$, state **one other** large-scale use of ammonia.

.....

[1]

[Total 4 marks]

12. Hydrogen iodide dissolves in water to give a solution of hydro-iodic acid, HI(aq). Its reactions are similar to those of hydrochloric acid, HC*l*(aq).

(i) A length of magnesium ribbon is added to hydrochloric acid.

Describe what you would see in this reaction.

.....

.....

[1]

(ii) Write a balanced equation for this reaction.

.....

[2]

[Total 3 marks]

13. Hydrochloric acid is a strong acid.

What is meant by the term *acid*?

.....

.....

[Total 1 mark]

14. Hydrochloric acid reacts with a solution of sodium carbonate.

(i) Write appropriate state symbols in the equation for this reaction shown below.

$2HCl$ ..... $+ Na_2CO_3$ ..... $\rightarrow 2NaCl$ ..... $+ CO_2$ ..... $+ H_2O$ .....

[1]

(ii) State what you would see to indicate that the reaction was taking place.

.....

[1]

[Total 2 marks]