

# F321: Atoms, Bonds and Groups

## Acids

49 Marks

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

Calcium nitrate,  $\text{Ca}(\text{NO}_3)_2$ , is an example of a salt.

The student prepares a solution of calcium nitrate by reacting dilute nitric acid,  $\text{HNO}_3$ , with the base calcium hydroxide,  $\text{Ca}(\text{OH})_2$ .

- (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.

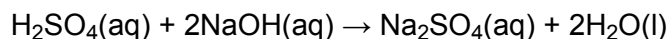
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[1]

[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<sup>3</sup> of 0.0880 mol dm<sup>-3</sup> aqueous sodium hydroxide, NaOH, is neutralised by 17.60 cm<sup>3</sup> of dilute sulfuric acid, H<sub>2</sub>SO<sub>4</sub>.



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

answer = ..... mol

[1]

- (ii) Determine the amount, in moles, of H<sub>2</sub>SO<sub>4</sub> used.

answer = ..... mol

[1]

- (iii) Calculate the concentration, in mol dm<sup>-3</sup>, of the sulfuric acid.

answer = ..... mol dm<sup>-3</sup>

[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<sub>2</sub>SO<sub>4</sub>•x H<sub>2</sub>O and a molar mass of 322.1 g mol<sup>-1</sup>.

- (i) What term is given to the '•x H<sub>2</sub>O' 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,  $(\text{NH}_4)_2\text{SO}_4$ , 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  $(\text{NH}_4)_2\text{SO}_4$ ?

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,  $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ .

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  $\text{MgSO}_4$ .

(i) Calculate the amount, in mol, of anhydrous  $\text{MgSO}_4$  formed.

amount = ..... mol

[2]

(ii) Calculate the amount, in mol, of H<sub>2</sub>O removed.

amount = ..... mol

[1]

(iii) Calculate the value of *x* in MgSO<sub>4</sub>•*x*H<sub>2</sub>O.

*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]

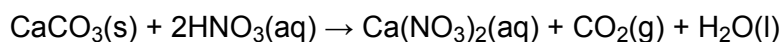
[Total 2 marks]

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

Calcium carbonate, CaCO<sub>3</sub>, reacts with acids such as nitric acid.

A student neutralised 2.68 g of CaCO<sub>3</sub> with 2.50 mol dm<sup>-3</sup> nitric acid, HNO<sub>3</sub>.

The equation for this reaction is shown below.



(i) Determine the amount, in mol, of CaCO<sub>3</sub> reacted.

amount = ..... mol

[2]

- (ii) Calculate the volume, in  $\text{cm}^3$ , of  $\text{CO}_2$  produced at room temperature and pressure.

volume = .....  $\text{cm}^3$

[1]

- (iii) Calculate the volume of  $2.50 \text{ mol dm}^{-3}$   $\text{HNO}_3$  needed to neutralise 2.68 g of  $\text{CaCO}_3$ .

volume = .....  $\text{cm}^3$

[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,  $\text{CaCO}_3$ , and calcium oxide,  $\text{CaO}$ , are white solids.

Dilute hydrochloric acid,  $\text{HCl}$ , can be used to identify whether a sample of white solid is  $\text{CaCO}_3$  or  $\text{CaO}$ .

- (i) Write equations, including state symbols, for the reaction of  $\text{HCl}$  with  $\text{CaCO}_3$  and the reaction of  $\text{HCl}$  with  $\text{CaO}$ .

.....  
.....

[3]

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

$\text{CaCO}_3$  .....

.....

$\text{CaO}$  .....

.....

[1]

[Total 4 marks]

9. A small amount of solid magnesium oxide,  $\text{MgO}$ , was reacted with excess dilute hydrochloric acid.

- (i) Define an acid.

.....

[1]

- (ii) Write a balanced equation for this reaction.

.....

[1]

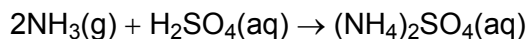
[Total 2 marks]

10. Chewing chalk has been used for many years to combat excess stomach acid and indigestion tablets often contain calcium carbonate,  $\text{CaCO}_3$ . 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.



- (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  $(\text{NH}_4)_2\text{SO}_4$ .

.....

[1]

- (iii) Apart from the manufacture of  $(\text{NH}_4)_2\text{SO}_4$ , 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,  $\text{HI}(\text{aq})$ . Its reactions are similar to those of hydrochloric acid,  $\text{HCl}(\text{aq})$ .

- (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*?

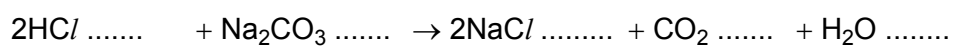
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[Total 1 mark]

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

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



[1]

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

.....

[1]

[Total 2 marks]