Foundations in chemistry

(Acids)

Total mark – 20

Question: 1

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]

1. (i) The H^+ ion in an (nitric) acid has been replaced by a metal ion
OR by a Ca^{2+} ion ✓

> *DO NOT ALLOW it has been produced by the reaction of an acid and a base as this is stated in the question.*
>
> *IGNORE references to replacement by NH_4^+ ions or positive ions.*
>
> *ALLOW H OR Hydrogen for H^+;*
> *DO NOT ALLOW Hydrogen atoms*
> *ALLOW Ca OR Calcium for Ca^{2+}.*
> *DO NOT ALLOW Calcium atoms*
> *ALLOW 'metal' for 'metal ion*

1

(ii) $2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2 (aq) + 2H_2O(l)$
Formulae ✓
Balance **AND** states ✓

> *ALLOW multiples*
> *ALLOW (aq) OR (s) for $Ca(OH)_2$*

2

(iii) Accepts a **proton OR** accepts H^+ ✓

> *ALLOW $H^+ + OH^- \rightarrow H_2O$*
>
> *ALLOW OH^- reacts with H^+ OR OH^- takes H^+*
> *ALLOW OH^- 'attracts' H^+ if 'to form water' is seen*
>
> *DO NOT ALLOW OH^- neutralises H^+ ('neutralises' is in the question)*
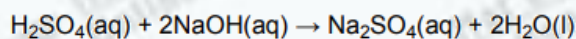
1

[4]

Question: 2

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

The student finds that 25.00 cm³ of 0.0880 mol dm⁻³ aqueous sodium hydroxide, NaOH, is neutralised by 17.60 cm³ 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 $Na_2SO_4 \cdot x\ H_2O$ and a molar mass of 322.1 g mol⁻¹.

(i) What term is given to the '·$x\ H_2O$' part of the formula?

....

[1]

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

answer = ...

[2]

[Total 6 marks]

2. **(a)** **(i)** Calculate correctly $\dfrac{0.0880 \times 25.0}{1000} = 2.20 \times 10^{-3}\,\text{mol}$

OR 0.00220 mol ✓

ALLOW 0.0022 OR 2.2 × 10⁻³ mol

1

(ii) Calculates correctly $\dfrac{0.00220}{2} = 1.10 \times 10^{-3}\,\text{mol}$

OR 0.00110 mol ✓

ALLOW 0.0011 OR 1.1 × 10⁻³ mol

ALLOW ECF for answer (i)/2 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes

1

(iii) $\dfrac{0.00110 \times 1000}{17.60} = 0.0625\,\text{mol dm}^{-3}$

OR $6.25 \times 10^{-2}\,\text{mol dm}^{-3}$ ✓

ALLOW 0.063 OR 6.3 × 10⁻² mol dm⁻³

ALLOW ECF for answer (ii) × 1000/17.60

OR

ECF from (i) for answer (i)/2 × 1000/17.60 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes

1

(b) **(i)** (The number of) Water(s) of crystallisation ✓

IGNORE hydrated OR hydrous

1

(ii) 142.1 ✓

ALLOW 142

ALLOW M_r expressed as a sum

ALLOW ECF from incorrect M_r and x is calculated correctly

$x = \dfrac{(322.1 - 142.1)}{18.0} = 10$ ✓

ALLOW ECF values of x from nearest whole number to calculator value

ALLOW 2 marks if final answer is 10 without any working

2

[6]

Question: 3

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]

3. (i) $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ ✓

ALLOW $2NH_4OH + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2H_2O$

ALLOW $NH_3 + H^+ \rightarrow NH_4^+$

ALLOW any correct multiple

IGNORE state symbols

1

(ii) when the H^+ in an acid is replaced by a metal ion **OR** an ammonium ion **OR** a + ion ✓

ALLOW H for H^+;
ALLOW 'metal' for 'metal ion'
i.e.: H in an acid can be replaced by a metal

1

(iii)   accepts a proton **OR** accepts H^+ ✓

                         ALLOW donates a lone pair
                         ALLOW removes H^+
                         ALLOW forms OH^- ions

                                                    1

(iv)   132.1 ✓

                         IGNORE units
                         NO OTHER ACCEPTABLE ANSWER

                                                    1

                                                    [4]

Question: 4

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

Epsom salts are crystals of hydrated magnesium sulfate, $MgSO_4 \cdot xH_2O$.

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]

4. (i) $M(MgSO_4) = 120.4$ OR 120 (g mol^{-1}) ✓

mol MgSO$_4$ = $\dfrac{1.51}{120.4}$ = 0.0125 mol ✓

ALLOW 0.013 up to calculator value of 0.012541528 correctly
rounded (from $M = 120.4$ g mol^{-1})
ALLOW 0.013 up to calculator value of 0.012583333 correctly
rounded (from $M = 120$ g mol^{-1})
ALLOW ecf from incorrect M i.e. 1.51 ÷ M

2

(ii) $\dfrac{1.57}{18.0}$ = 0.0872(2) (mol) ✓

ALLOW 0.09 up to calculator value of 0.08722222

1

(iii) × = 7 ✓

ALLOW ecf i.e. answer to (ii) ÷ answer to (i)
ALLOW correctly calculated answer from 1 significant figure
up to calculator value, ie, × does not have to be a whole
number. Likely response = 6.95 ✓

1

[4]

Question: 5

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]

5. (i) $Ca(OH)_2$ ✓

IGNORE charges, even if wrong

1

(ii) $Ca(NO_3)_2$ ✓

IGNORE charges, even if wrong

1