05 Acids, Bases and Salts

Set A **Answer key**

A From the lesson

25 MARKS

1 **B** Hydrochloric acid has the higher concentration of H^+ ions. [1]

Both have the same concentration, but only hydrochloric acid is fully ionised, so it gives more H^+ and has the lower pH.

Ethanoic acid is weak: only some of its molecules ionise.

2 **C** aluminium oxide [1]

Aluminium oxide is amphoteric, so it reacts with acids and with alkalis.

Copper(II) oxide is basic, carbon dioxide is acidic and carbon monoxide is neutral.

3 **B** SO_4^{2-} [1]

A conjugate base has one H^+ fewer than its acid: HSO_4^- loses H^+ to give SO_4^{2-}.

H_2SO_4 is the conjugate acid of HSO_4^-.

4 **A** $Ba(NO_3)_2(aq)$ and $Na_2SO_4(aq)$ [1]

One solution gives Ba^{2+} ions and the other gives SO_4^{2-} ions, which join as insoluble $BaSO_4$.

Barium carbonate is insoluble, so it gives no Ba^{2+} ions, and C and D contain no sulfate.

5 **C** 0.160 mol dm^{-3} [1]

$n_{H_2SO_4} = 0.100 \times 0.0200 = 2.00 \times 10^{-3}$ mol, and each H_2SO_4 neutralises 2NaOH, so $n_{NaOH} = 4.00 \times 10^{-3}$ mol.

$c = 4.00 \times 10^{-3} \div 0.0250 = 0.160$ mol dm^{-3}. Option B forgets the 2 : 1 ratio.

6 **(a)** Zinc chloride and hydrogen [1]

(b) The solid has no free ions. In water the acid ionises, and the ions carry the current. [1]

7 $Mg(OH)_2(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$ [1]

8

No. Only bases that dissolve in water are alkalis. Copper(II) oxide is a base but not an alkali. **[1]**

9

(a) Three pH units: 10 × 10 × 10 = 1000 times **[1]**

(b) Yellow **[1]**

10

(a) HSO_4^- **[1]**

(b) NH_4^+ **[1]**

11

(a) HCl, because it gives a proton to NH_3. **[1]**

(b) There is no water, so no $H^+(aq)$ or $OH^-(aq)$ forms. **[1]**

12

(a) Excess copper(II) oxide or carbonate with dilute sulfuric acid, filter, crystallise. **[1]**

(b) Potassium hydroxide or carbonate with dilute nitric acid by titration, then crystallise. **[1]**

(c) Precipitation: aqueous silver nitrate with a soluble chloride such as sodium chloride, then filter, wash and dry. **[1]**

13

$n_{HCl} = 0.250 \times 0.01500 = 3.750 \times 10^{-3}$ mol $= n_{NaOH}$

$c = 3.750 \times 10^{-3} \div 0.0250 = 0.150$ mol dm^{-3} **[2]**

14

Methyl orange.

Hydrochloric acid is strong and ammonia is a weak base, so the sudden pH change at the equivalence point lies in the acidic range. **[2]**

15

HCl added 0.05000 mol, left over 0.01000 mol, so 0.04000 mol reacted.

$CaCO_3 + 2HCl$, so $n_{CaCO_3} = 0.02000$ mol, mass = 2.002 g

purity = 2.002 ÷ 2.50 × 100% = 80.1% **[3]**

B Practice

17 MARKS

16 **C** The pH of ethanoic acid is higher. [1]

Ethanoic acid is weak and only partly ionised, while sulfuric acid is strong, so at the same concentration ethanoic acid has fewer H^+ ions and the higher pH.

Weak acids also react with carbonates. Group 1 oxides are basic. Nitric and hydrochloric acids are both strong and monobasic, so they have the same pH at the same concentration.

17 **D** Hydrochloric acid releases more H^+ ions in water. [1]

Hydrochloric acid is fully ionised, so at the same concentration it gives more H^+ ions and a lower pH.

Hydrochloric acid ionises completely, not partially, and the pH depends on the H^+ ions, not on the size or elements of the molecule.

18 **D** The $HNO_3(aq)$ is more concentrated. [1]

Both acids are strong and fully ionised, so the lower pH of the nitric acid means it has more H^+ per volume: it is more concentrated.

Neither acid is weak, and relative molecular mass does not set the pH.

19 **A** X < W < Y < Z [1]

Sulfuric acid is strong and dibasic, so it gives the most H^+ and the lowest pH, then hydrochloric acid (strong, monobasic).

Ethanoic acid is weak, so its pH is higher, but still below 7. Sodium hydroxide is an alkali, pH above 7.

20 **C** row C [1]

pH 13 is strongly alkaline: there are far more OH^- ions than H^+ ions.

Every aqueous solution contains some H^+ ions, so the concentration is low, not zero.

21 **D** The concentration of hydrogen ions in X is higher. [1]

Red means a very low pH and yellow a pH a little below 7, so both are acidic and X has the higher concentration of H^+.

Y is acidic too, not alkaline, so it also reacts with zinc, more slowly.

22 **D** 3 and 4 [1]

A pH below 7 and a reaction with a base (copper(II) oxide) to form a salt are properties of acids.

Statement 1 shows sulfate ions ($BaSO_4$ precipitates) and statement 2 shows water. Neither shows it is an acid.

23 **B** 1 and 3 [1]

Sulfur dioxide is an acidic oxide, so its solution has pH below 7. Carbon dioxide is acidic and ammonia is an alkali, so they react to make a salt.

Potassium oxide dissolves to form an alkali, which turns red litmus blue. Carbon monoxide is neutral and reacts with neither acids nor alkalis.

24 **B** MgO [1]

MgO is a basic oxide, so it does not react with an alkali.

Al_2O_3 is amphoteric, and P_4O_{10} and SO_2 are acidic, so all three react with sodium hydroxide.

25 **D** $N_2H_4O_3$ [1]

The gas is ammonia, so the fertiliser is an ammonium salt. An ammonium nitrate is NH_4NO_3.

NH_4NO_3 has 2 N, 4 H and 3 O: $N_2H_4O_3$, already the simplest ratio.

26 **A** calcium carbonate and sodium chloride [1]

The method separates an insoluble solid from a soluble one. Sodium chloride dissolves in water and calcium carbonate does not, so filtering leaves calcium carbonate as the residue.

Magnesium and iron are both insoluble. Sodium chloride and copper(II) sulfate are both soluble. The two acids are both liquids that mix with water.

27 **C** dissolve in water, then separating funnel, then crystallisation [1]

Calcium nitrate dissolves in water. Oil does not mix with water, so the two liquids form layers and the separating funnel removes the oil.

Crystallisation then gives pure solid calcium nitrate from the solution. Filtration is not needed, because there is no insoluble solid to remove.

28 **B** dissolve in water, filtration, crystallisation [1]

Copper(II) sulfate dissolves in water but calcium carbonate does not, so filtration leaves the calcium carbonate behind as the residue.

Crystallising the filtrate gives the hydrated crystals. Heating to remove all the water would destroy the water of crystallisation, and distillation does not separate one solid from another.

29 **B** Add excess magnesium carbonate to nitric acid. [1]

Magnesium nitrate is soluble and magnesium carbonate is insoluble: excess carbonate uses up all the acid and the leftover solid is filtered off.

Excess acid would stay in the product. Magnesium hydroxide is insoluble, so it cannot be titrated, and mixing two soluble salts gives no precipitate.

30

B row B [1]

Potassium salts are made by titration. Zinc reacts with dilute sulfuric acid. Copper does not react with dilute acids, so copper(II) sulfate is made from its carbonate.

Silver chloride is insoluble, so it is made by precipitation.

31

C calcium sulfate, lead(II) sulfate, silver chloride [1]

Precipitation makes insoluble salts: calcium sulfate (sparingly soluble), lead(II) sulfate and silver chloride.

Every nitrate is soluble, so calcium nitrate and silver nitrate cannot be made by precipitation.

32

C 0.06 mol/dm^3 [1]

$n_{NaOH} = 0.1 \times 0.030 = 0.0030$ mol. $2NaOH + H_2SO_4$, so $n_{H_2SO_4} = 0.0015$ mol.

$c = 0.0015 \div 0.025 = 0.06$ mol/dm^3.