05 Acids, Bases and Salts

Set B **Answer key**

A Competition questions

25 MARKS

1 **A** 2.1 g [1]

0.0250 mol of H_2S means 0.0250 mol of MgS, which used 0.0500 mol of H^+. The other 0.125 − 0.0500 = 0.0750 mol of H^+ reacted with CaO.

n_{CaO} = 0.0375 mol, mass = 0.0375 × 56.1 = 2.1 g.

2 **B** 47.0% [1]

n_{CO_2} = 0.45 ÷ 44.0 = 0.0102 mol, so $n_{CaMg(CO_3)_2}$ = 0.00511 mol.

M_r = 184.4, so the mass is 0.943 g and the purity is 0.943 ÷ 2.00 × 100% = 47.0%.

3 **B** Experiments 1 and 2 produced the same volume of gas. [1]

Both are monobasic acids with the same amount in moles. As the magnesium reacts, the weak acid keeps ionising until all of it has reacted, so both give the same volume of hydrogen.

The weak acid has fewer H^+ ions at any moment, so it reacts more slowly. Sulfuric acid is dibasic, so it gives twice the H^+ and reacts fastest.

4 **C** K is strong and L is weak. [1]

K conducts far better and reacts faster with magnesium, so at the same concentration it has many more ions: K is fully ionised, a strong acid.

L has few ions, so it is only partly ionised: a weak acid.

5 **A** 1.0 mol $(NH_4)_3PO_4$ [1]

Each NH_4^+ gives one NH_3.

A contains 3.0 mol of NH_4^+. B, C and D each contain only 2.0 mol.

6 **D** The solution is weakly acidic. [1]

Sodium nitrate is the salt of a strong acid (nitric acid) and a strong alkali (sodium hydroxide), so its solution is neutral, not acidic.

$NaNO_3$ gives one Na^+ and one NO_3^-, and 0.10 mol in 2.00 L is 0.05 mol per litre.

7

B gastric juice [1]

Gastric juice contains hydrochloric acid, a strong acid, so it has the lowest pH.

Vinegar is a weak acid. Baking soda and ammonia solutions are alkaline.

8

A weakly acidic. [1]

Unpolluted air contains carbon dioxide, an acidic oxide, which dissolves in rain to form carbonic acid.

Carbonic acid is a weak acid, so the rain is only weakly acidic.

9

D dilute NaOH [1]

Al_2O_3 is amphoteric and P_4O_{10} is acidic, so both react with and dissolve in sodium hydroxide. Magnesium oxide is basic, so it does not.

The acids would dissolve the magnesium compound as well.

10

A BH_3 and BH_4^- [1]

A conjugate pair differs by one H^+. BH_4^- has one more H and one more negative charge than BH_3: it differs by a hydride ion, H^-.

B, C and D each differ by one H^+.

11

B Ammonia accepts a lone pair. [1]

A Lewis base donates a lone pair: ammonia gives its lone pair to H^+ to form NH_4^+.

NH_4^+ is tetrahedral with four equal N–H bonds, and it reacts with an alkali to give ammonia.

12

D 1, 2 and 3 [1]

In 1 and 2, an NH_3 molecule uses its lone pair to accept a proton, which is a Lewis base action.

In 3, each NH_3 gives its lone pair to Ag^+, forming a dative bond.

13

C 2 and 3 [1]

NH_4^+ gives a proton to NH_2^-, so it is the acid, and NH_2^- and NH_3 differ by one H^+.

NH_2^- donates a lone pair to the proton, so statement 1 is wrong.

14

B The B atom is not electron deficient. [1]

N gives its lone pair to B, so B now has four bond pairs, an octet.

$(CH_3)_3N$ is the Lewis base and BF_3 the Lewis acid. Both N and B are tetrahedral in the product, and there is no H on N, O or F, so no hydrogen bonds.

15 **B** Brønsted–Lowry base [1]

NH_4^+ gives a proton to CO_3^{2-}, leaving NH_3.

The carbonate ion accepts the proton, so it is a Brønsted–Lowry base.

16 **C** 55.2% [1]

$MgSO_4(aq) + 2NaOH(aq) \rightarrow Mg(OH)_2(s) + Na_2SO_4(aq)$. $n_{MgSO_4} = 1.20 \div 120.4 = 9.97 \times 10^{-3}$ mol = $n_{Mg(OH)_2}$.

Theoretical mass = $9.97 \times 10^{-3} \times 58.3 = 0.581$ g, so the yield is $0.32 \div 0.581 \times 100\% = 55\%$.

17 **B** aqueous lead(II) nitrate and sodium nitrate [1]

$Pb(NO_3)_2 + 2NaCl \rightarrow PbCl_2 + 2NaNO_3$. 1.0×10^{-3} mol of $Pb(NO_3)_2$ needs 2.0×10^{-3} mol of NaCl, but only 1.5×10^{-3} mol is present.

NaCl is the limiting reagent, so some lead(II) nitrate is left over, along with the sodium nitrate formed.

18 **D** add excess nitric acid, filter, then rinse and dry [1]

Lead(II) carbonate reacts with nitric acid to form soluble lead(II) nitrate, while lead(II) sulfate is insoluble and stays as a solid. Filtering, rinsing and drying the residue gives pure lead(II) sulfate.

Hydrochloric acid would form insoluble lead(II) chloride, which would stay mixed with the lead(II) sulfate. Crystallising is not needed because the product is the residue, not a dissolved solid.

19 **C** X_2SO_4 [1]

$n_{hydroxide} = 0.020$ mol and $n_{H_2SO_4} = 0.010$ mol, so 0.020 mol of H^+ reacts with 0.020 mol of the hydroxide: one OH^- each, XOH.

X forms X^+, so its sulfate is X_2SO_4.

20 **B** 4.5 g [1]

$Li_2O + H_2O \rightarrow 2LiOH$, and $2LiOH + H_2SO_4$, so 1 Li_2O reacts with 1 H_2SO_4. $n_{H_2SO_4} = 0.015$ mol = n_{Li_2O} in 25.0 cm^3.

In 250 cm^3: 0.15 mol, mass = $0.15 \times 29.8 = 4.5$ g.

21 **B** Ethanoic and nitric acids need the same volume. [1]

In a titration a weak acid still reacts completely, so ethanoic acid, monobasic like nitric acid, needs the same volume.

Sulfuric acid is dibasic, so it needs twice the volume.

22 **C** 5 **[1]**

$n_{NaOH} = 0.147 \times 0.01225 = 1.80 \times 10^{-3}$ mol = $n_{aspirin}$, mass = $1.80 \times 10^{-3} \times 180 = 0.324$ g.

$0.324 \div 0.0648 = 5$ grains.

23 **A** 0.750 mol/dm^3 **[1]**

$n_{NaOH} = 2.50 \times 0.0150 = 0.0375$ mol. A dibasic acid reacts with 2NaOH, so $n_{oxalic\ acid} = 0.01875$ mol.

$c = 0.01875 \div 0.0250 = 0.750$ mol/dm^3. Option C forgets that the acid is dibasic.

24 **D** CaH_2 **[1]**

$n_{HCl} = 0.0480$ mol = $n_{OH^-} = n_{H^-}$ in 1.01 g.

CaH_2 (M_r 42.1): $1.01 \div 42.1 = 0.0240$ mol, with 2 H^- each, 0.0480 mol. LiH gives 0.127 mol, NaH 0.0421 mol and MgH_2 0.0768 mol.

25 **D** HCl_2^- **[1]**

NaOH reacts with the acidic H: 2.46×10^{-3} mol. Ag^+ precipitates every Cl^-: 4.92×10^{-3} mol.

H : Cl = 1 : 2, and with one $(C_2H_5)_4N^+$ the anion has charge 1–: HCl_2^-.