

Solutions

Original marking guidance: M1 method, A1 accuracy, B1 reasoning. Alternative correct balanced ionic equations are acceptable when they retain the stated products and conditions.

2.1 $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$; $\text{Mg} + \text{Cl}_2 \rightarrow \text{MgCl}_2$. Na^+ requires one Cl^- , while Mg^{2+} requires two Cl^- for neutrality. Both metals are oxidised from 0 to +1/+2; chlorine is reduced from 0 to -1.

2.2 $\text{Cl} > \text{Br} > \text{I}$. Greater radius and shielding down the group weaken attraction despite greater nuclear charge. Electronegativity concerns the shared bonding pair; oxidising power concerns accepting electrons in redox, so the two descriptions must not be conflated.

2.3 Cl_2 : pale green aqueous, pale yellow-green organic; Br_2 : orange/brown aqueous, orange organic; I_2 : brown aqueous, purple/violet organic. KI gives a purple organic layer containing I_2 ; KCl retains orange Br_2 . $\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$. Bromine is a weaker oxidising agent than chlorine and does not oxidise Cl^- under these conditions. Colour interpretation explicitly uses cyclohexane rather than the brown aqueous-iodine colour.

3.1 $\text{Br}_2 + 2\text{NaOH} \rightarrow \text{NaBr} + \text{NaBrO} + \text{H}_2\text{O}$; $3\text{I}_2 + 6\text{NaOH} \rightarrow 5\text{NaI} + \text{NaIO}_3 + 3\text{H}_2\text{O}$. Bromine products contain Br -1 and +1; iodine products contain I -1 and +5. Bleach contains chlorate(I)/hypochlorite, ClO^- . $\text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HCl} + \text{HClO}$. These are disproportionation reactions: some halogen is reduced and some oxidised.

3.2 $2\text{HI} + \text{H}_2\text{SO}_4 \rightarrow \text{I}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$; $6\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 3\text{I}_2 + \text{S} + 4\text{H}_2\text{O}$; $8\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 4\text{I}_2 + \text{H}_2\text{S} + 4\text{H}_2\text{O}$. Sulfur changes +6 $\rightarrow$ +4, 0 and -2 respectively. Iodide/HI is oxidised from I -1 to I_2 0. The oxidising acid consumes the desired HI and introduces iodine/reduced-sulfur products, preventing pure HI preparation by this route.

3.3 $n(\text{NaOH}) = 0.1000 \times 0.02460 = 0.002460 \text{ mol}$; $\text{HCl}:\text{NaOH} = 1:1$; $c(\text{HCl}) = 0.002460/0.02500 = 0.09840 \text{ mol dm}^{-3}$. Rinse the pipette with HCl, burette with NaOH, and flask with deionised water; transfer the aliquot with the pipette using a filler. Fill the burette jet, remove the funnel and read initial/final menisci at eye level. Add indicator and swirl; approach the endpoint dropwise over a white tile, rinsing flask walls with deionised water if needed. Phenolphthalein changes from colourless to the first persistent pale pink as slight alkali excess is reached. Obtain a rough titre, then repeat accurately to concordance and average the accepted concordant titres, rather than including the rough run.

3.4 Clean the test wire according to the approved method, using hydrochloric acid and heating until no colour remains, and avoid carrying material from one salt to the next. Sodium is yellow; potassium lilac. Calcium is brick-red; strontium crimson-red. Keep the wire, sample-loading method and flame region/conditions matched. Sodium contamination gives a strong yellow signal that may mask another salt, so a contaminated yellow flame alone does not establish sample identity. Bubble the evolved CO_2 through limewater: it turns milky from CaCO_3 ; this is distinct from a flame test.

3.5 Use comparable measured molar amounts and similar particle size/apparatus; keep the heating rate and other apparatus conditions matched. Record sample temperature at an agreed detectable onset/extent of decomposition, rather than interpreting bubble time alone as a decomposition temperature. CO_2 turns limewater milky; O_2 relights a glowing splint; NO_2 is a brown gas with acidic behaviour on damp indicator. These

are observations in an approved ventilated supervised setup, not instructions to smell or handle decomposition gases independently. The detected onset depends on apparatus and sensitivity; compare it consistently rather than claiming a universal sharp decomposition temperature.