1.

(d) A sample of aqueous calcium halide, $CaX_2(aq)$, contains either chloride, bromide or iodide ions.

Complete Table 2.1 to describe a two-step process that could be used to identify the halide ion present.

Table 2.1

step	method	observation with $CaCl_2$	observation with $CaBr_2$	observation with CaI_2
step **1**				
step **2**				

step	method	observation with $CaCl_2$	observation with $CaBr_2$	observation with CaI_2
step **1**	$AgNO_3(aq)$ ($+HNO_3(aq)$)	white ppt	cream **OR** off-white ppt	(pale) yellow ppt
step **2**	NH_3 (aq)	(ppt) dissolves / (completely) soluble (in dilute or conc) OR (forms) colourless solution	(ppt) partly soluble / slightly soluble (in dilute or conc) **ALLOW** (ppt) dissolves in excess (in dilute or conc) **ALLOW** (ppt) soluble in **conc.**NH_3	(ppt) insoluble / solid remains (in dilute or concentrated)

M1 step **1** $AgNO_3(aq)$ / silver nitrate solution **AND** step **2** $NH_3(aq)$ / ammonia solution / dilute NH_3 / concentrated NH_3

M2 ALL solid / precipitate **AND** correct colours described in row 1

M3 correct observations on addition of ammonia

2. Identify the type of reaction that occurs when NaI(s) reacts with concentrated H2SO4 to form HI(g)
   - acid-base reaction

3. Write an equation for the reaction of HI(g) and concentrated H2SO4

   $8HI + H_2SO_4 \rightarrow 4I_2 + H_2S + 4H_2O$

   OR

   $8H^+ + 8I^- + H_2SO_4 \rightarrow 4I_2 + H_2S + 4H_2O$

   ALWAYS give the final reaction!!

4. Explain why HI(g) reacts with concentrated H2SO4 whereas HCl does not
   - HI / I– is stronger reducing agent compared to Cl – / HCl

5.

(ii) Complete Table 2.1 with information for sodium chloride and phosphorus(V) chloride.

Table 2.1

	sodium chloride	phosphorus(V) chloride
state at room temperature		
name of change which occurs on addition of water		
pH of final solution		

	sodium chloride	phosphorus (V) chloride
state at room temperature	solid	solid
name of change which occurs on addition of water	dissolves	hydrolysis
pH of final solution	7	1–2

NOTE:

- PCl5 is solid at room temperature
- PCl3 and SiCl4 are liquids at room temperature

6. Suggest an equation for the reaction of NaTs and Br2. Assume that Ts follows the same trends as the other elements in Group 17. Explain your answer.

-

$$2NaTs + Br_2 \rightarrow 2NaBr + Ts_2$$

OR $2Ts^- + Br_2 \rightarrow 2Br^- + Ts_2$

- Ts– reduces Br / Br2 OR reducing strength of halide (ion) increases down the group

7. When 1cm3 of MgCl2(aq) is added to 1cm3 of Br2(aq) in a test-tube, the solution remains orange. Explain this observation.
   - bromine / Br2 is not a strong enough / too weak as a oxidising agent to oxidise chloride / Cl–

8. Describe what is observed when SrI2(aq) reacts with concentrated sulfuric acid.
   - White precipitate
   - effervescence/ misty fumes
   - Grey solid/ purple gas

- Yellow solid
- Rotten egg smell

9. Explain how NH3 acts as a base
   - accepts a proton / H+ OR donates a (lone) pair of e–

10. State the reagent and conditions required for the formation of sodium chlorate(V) from Cl 2(g).
    - Hot NaOH(aq)

11. Write an equation for the reaction of chlorine with water.

$$Cl_2 + H_2O \rightleftharpoons HOCl + HCl$$

REMEMBER the reversible sign!!

12. Write an equation for the reaction of chlorine with hot NaOH(aq).

$$NaClO + H_2O_2 \rightarrow O_2 + NaCl + H_2O$$

13. Explain why hydrogen iodide is not prepared by adding concentrated sulfuric acid to sodium iodide.
    - HI(g) is not the only gaseous product OR SO2 and / or H2S and / or I2(g) is also made
    - HI / iodide ion is oxidised OR H2SO4 oxidises HI OR HI reduces sulfuric acid

14.

(a) The elements of Group 17 are called halogens.

Complete Table 1.1.

Table 1.1

halogen	colour at 293 K
chlorine	
bromine	
iodine	

halogen	colour at 293 K
chlorine	green
bromine	brown
iodine	(dark) grey

State chlorine as yellow-green

15. State the trend in volatility of the halogens chlorine, bromine and iodine. Explain your answer.
    - volatility decreases
    - more electrons in molecules
    - so increased strength of instantaneous dipole – induced dipole forces of attraction

16. Iodine is made by reacting bromine with sodium iodide. state the role of bromine in the reaction. Explain your answer.
    - Oxidising agent AND
    - Removes and electron from iodide ions // increases the oxidation number of iodide ion.

17. Concentrated sulfuric acid is added to separate samples containing equal amounts of NaC*l*, NaBr and NaI. All three samples initially react to produce the hydrogen halide. Write an equation to describe the acid–base reaction that occurs when concentrated sulfuric acid reacts with NaBr.

    $NaBr + H_2SO_4 \rightarrow HBr + NaHSO_4$
    OR
    $2NaBr + H_2SO_4 \rightarrow 2HBr + Na_2SO_4$

    NOTE: this is an acid-base reaction!!

18. Deduce which sodium halide, NaCl, NaBr or NaI, produces the largest percentage yield of hydrogen halide when concentrated sulfuric acid is added. Explain your answer by considering the relative reactivity of the halide ions as reducing agents.
    - Identity of sodium halide: sodium chloride
    - Explanation:
        - Cl– is not a strong enough reducing agent to reduce H2SO4 // ability to behave as reducing agents increases down the group
        - Br– & I– are strong enough reducing agents to react further with the S in H2SO4

19. State how Cl 2 is used in water purification.
    - Kills bacteria/ microbes/ micro-organisms

20. State and explain the relative thermal stabilities of the hydrogen halides, HX.
    - thermal stability decreases down group
    - H—X bond energy / bond strength decreases

21. Explain why different sulfur-containing products are produced when different halide ions reacts with concentrated H2SO4
    - halides are better / stronger / more able reducing agents / are more easily oxidised **down group**

22. State the meaning of *volatile*
    - Easily vaporised/ easily evaporates/ turns to gas easily

23. State what is observed when chlorine reacts with hydrogen
    - Green colour disappears

24.

A student does three tests on separate samples of NaC*l*(aq).

Complete Table 1.2 with the observations the student makes in each test.

Table 1.2

test	test	observations
1	addition of a few drops of $Br_2(aq)$	
2	addition of a few drops of concentrated H_2SO_4	
3	addition of a few drops of dilute $AgNO_3(aq)$	

- No visible reaction
- No visible reaction / solution remains colourless
- White precipitate forms

NOTE: when H2SO4 is added to NaCl, HCl forms as aqueous NOT as gas!! Thus there is no visible reaction. The solution will remain colourless

25. Describe and explain the relative reactivity of the halogens down the group when they react with hydrogen to form HCl, HBr and HI.

- Reaction less vigorous down the group
- electronegativity decreases OR less attractive to e– addition OR weaker oxidising agent OR greater nuclear charge outweighing increased shielding

26.

(ii) In reaction 2, NaC*l* reacts with concentrated H_2SO_4 to form HC*l* and $NaHSO_4$.
When NaBr reacts with concentrated H_2SO_4, the products include Br_2 and SO_2.

Identify the type(s) of reaction that occur in each case by completing Table 3.1.
Explain the difference in these reactions.

Table 3.1

reactants	type(s) of reaction
NaC*l* and concentrated H_2SO_4	
NaBr and concentrated H_2SO_4	

explanation .....

.....

M1: *All three correct for two marks:*
row 1 • acid–base
row 2 • acid–base • redox

M2: *explanation*
H_2SO_4 is strong enough to oxidise / is an oxidising agent with NaBr / HBr / bromide

NOTE:
NaCl + H2SO4 is an acid base reaction
- H2SO4 is the acid because it donates H+ / proton
- Cl– is a conjugate base because it accepts the H+ / proton to form HCl

27. An excess of Cl– (aq) is added to 1cm3 of Br2(aq). Describe what is observed. Explain your answer.
- orange colour (of solution) remains / no visible reaction
- bromine/Br2 cannot oxidise chloride/Cl– OR bromine/Br2 is not a strong enough oxidising agent (to oxidise chloride/Cl–)

28. A sample of BaBr2 is dissolved in water. Chlorine gas is bubbled into the solution. Describe the observations for this reaction.

- solution / mixture / liquid turns from colourless to orange or brown

29. Name the type of reaction that occurs when BaBr2 reacts with chlorine gas.
    - Displacement

30. Compound Y is a pure **insoluble** solid which contains halide ions. A single reagent is added directly to compound Y to determine the halide ion present. Identify the reagent added. State the observation which would confirm that Y contains bromide ions.
    - Reagent: concentrated sulfuric acid
    - Observation: brown vapour/ gas forms

31. Sodium halide salts react with concentrated sulfuric acid at room temperature. Name this type of reaction.
    - Displacement / acid-base

32. NaI(s) reacts with concentrated sulfuric acid, at room temperature, to form steamy fumes. Identify the chemical responsible for the steamy fumes.
    - Hydrogen iodide / HI

      CAREFUL: steamy fumes could be HCl, HBr OR HI!!

33. Explain the differences in observations, at room temperature, when NaI(s) reacts with concentrated sulfuric acid compared to those for NaCl(s).
    - iodide ions are stronger reducing agents than chloride ions
    - HI / iodide is oxidised OR HCl / chloride is not oxidised

34. Describe what is observed when SrI2 reacts with concentrated sulfuric acid.
    - white precipitate
    - yellow solid
    - (dark) grey solid / purple gas
    - effervescence / misty fumes
    - rotten egg smell

35. Suggest one change you would observe, ignoring temperature changes, when bromine reacts with methanoic acid.

    $$Br_2(aq) + HCO_2H(aq) \rightarrow 2HBr(aq) + CO_2(g)$$

    - solution turns (from brown / orange to colourless / decolorises