

1. (a) (i) • LiCl red/scarlet/crimson/carmine red **(1)**
 • NaBr orange/yellow **(1)**
 • KI lilac/purple/mauve/pink/violet/lavender **(1)** 3
- (ii) • Excited electrons **(1)**
 • Move down energy levels **(1)** 2
- (b) (i) • LiCl - white/steamy fumes
 • NaBr - brown/orange vapour or liquid
 • KI - purple vapour / dark solid or liquid or residue 4
- (ii) $\text{LiCl(s)} + \text{H}_2\text{SO}_4\text{(l)} \rightarrow \text{LiHSO}_4\text{(s)} + \text{HCl(g)}$
 formulae **(1)**, states **(1)**
 or $2\text{LiCl(s)} + \text{H}_2\text{SO}_4\text{(l)} \rightarrow \text{Li}_2\text{SO}_4\text{(s)} + 2\text{HCl(g)}$
 formulae **(1)**, states **(1)** 2
- [11]**
2. (a) (i) Loss of electrons 1
 (ii) A substance which gains/removes/accepts electrons 1
 (iii) • Chlorine (is stronger oxidising agent)
 • So it can accept electrons from Br^- /
 so it can displace Br^- / so can oxidise Br^- 2
- (b) (i) $3\text{OCl}^- \rightarrow \text{ClO}_3^- + 2\text{Cl}^-$
 formulae + charges **(1)**, balancing **(1)** 2
 (ii) Disproportionation 1
- (c) (i) SO_2 : +4
 SO_4^{2-} : +6 2
 (ii) Oxidised because oxidation number of S becomes more positive/sulphur loses electrons 1
 (iii) • Starch/any named non polar solvent: hexane, chloroform, volasil
 • Blue-black/purple 2
- [12]**
3. (a) (i) $\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HCl}$ **(1)**
 or
 $2\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HCl}$ **(1)** 1
- (b) (i) add silver nitrate (solution) / correct formula AgNO_3 (aq) **(1)**

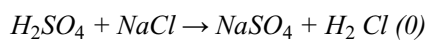
- white ppt /solid **(1)**
soluble in dilute ammonia /ammonia solution **(1)**
or
add lead nitrate/ethanoate (solution) **(1)**
white ppt. **(1)**
soluble in hot water **(1)**
Any feasible correct chemical method can score the marks here 3
- (ii) dissociates /reacts/ionises/changes into ions (as it dissolves) **(1)**
forming H^+ ions / H_3O^+ ions/ donates a proton to water.
This makes the solution an acid **(1)** 2
- (i) damp litmus paper **(1)** bleached **(1)**
or
damp starch-iodide paper **(1)** goes blue **(1)**
Displacement acceptable 2
- (ii) $[\text{+4}] [\text{-1}]$ **(1)**
 $[\text{+2}] [\text{-1}] [\text{0}]$ **(1)**
positive charge not essential 2
- (d) (hydrogen) iodide is more easily oxidized / loses electrons more easily than (hydrogen) chloride **(1)**
because larger (than chloride) **(1)**
Could argue from the reducing power of the iodide / chloride for the first mark 2
- [12]**
4. (a) (i) $+7/7+/\text{VII}$ 1
(ii) $+7/7+/\text{VII}$ 1
- (b) (i) $\text{Sn}^{2+} \rightarrow \text{Sn}^{4+} + 2\text{e}^{(-)}$ OR $\text{Sn}^{2+} - 2\text{e}^{(-)} \rightarrow \text{Sn}^{4+}$ **(1)**
 $\text{I}_2 + 2\text{e}^{(-)} \rightarrow 2\text{I}^{-}$ **(1)** 2
- (ii) $\text{Sn}^{2+} + \text{I}_2 \rightarrow \text{Sn}^{4+} + 2\text{I}^{-}$
IGNORE state symbols 1
- [5]**

5. (a) $\text{H}_2\text{SO}_4 + \text{NaCl} \rightarrow \text{NaHSO}_4 + \text{HCl}$
 $\text{H}_2\text{SO}_4 + 2\text{NaCl} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HCl}$ 2

Either version

State symbols (Ignore these)

Multiples



Correct formulae (1) Balanced (1)

Second mark depends on first being correct

*4 correct formulae with an additional existing molecule
eg H_2 , SO_2 Max 1*

- (b) (i) Sulphur: from +6 to +4 **(1)**
 Bromine: from -1 to 0 **(1)** 2

Accept sign after value,

Roman numerals

Incorrect signs

- (ii) Increase in ox number of bromine = $2 \times 1 / 2$ **(1)**
One S decreases in ox number by 2 (1)
 Must be clear that one S atom is unchanged/only one S
 changes for second mark.
 [Look for oxidation no. written under elements in equation] 2

*Accept increase in oxidation number of Br = decrease in
oxidation number of S, without specifying values (1)*

Reject explanations in terms of electrons

- (c) (i) Going down group
 Number of electrons increases **(1)**
Accept reverse argument going up group
Reject arguments based on quantum shells.
 So Van der Waals force (between molecules) increases **(1)**
Ignore comments on radius of atom 2

Reject vdw for Van der Waals

- (ii) Boiling point between 200 and 300 (K) (1)
 -73 to +27 if value quoted in °C
 Hydrogen bonding is present (1)
 Stronger forces between molecules /stronger intermolecular forces (than in other hydrogen halides.) (1) 3

Accept B pt 155 – 175(K) with explanation that there are fewer electrons in HF for maximum 1 mark.

*Accept boiling point in correct range, with comment on **much** stronger dipole in HF and stronger intermolecular forces (2)*

[11]

6. (a) Any statement that means the number gets less
 Eg
 Decrease (in oxidation number of an element)
 Reduction of ON
 Lowering of ON
 ON becomes more negative
 ON becomes less positive 1

Reject 'just' Gain of electrons

- (b) (i) $2\text{NaBr} + 3\text{H}_2\text{SO}_4 \rightarrow 2\text{NaHSO}_4 + \text{SO}_2 + \text{Br}_2 + 2\text{H}_2\text{O}$
 OR
 $2\text{NaBr} + 3\text{H}_2\text{SO}_4 \rightarrow 2\text{NaHSO}_4 + \dots\text{SO}_2 + \dots\text{Br}_2 + 2\text{H}_2\text{O}$
 OR
 $2\text{NaBr} + 3\text{H}_2\text{SO}_4 \rightarrow 2\text{NaHSO}_4 + 1\text{SO}_2 + 1\text{Br}_2 + 2\text{H}_2\text{O}$ 1

- (ii) H_2SO_4 : +6 / 6 / VI / 6+
 HSO_4^- : +6 / 6 / VI / 6+
 SO_2 : +4/4/IV / 4+
 H_2S : -2 / -II / 2-
 All four correct 2 marks
 Any 3 correct 1 mark 2

Reject superscript + e.g S^{6+}

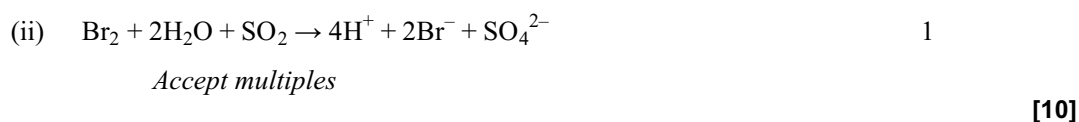
- (iii) Change in ON of S increases down (halide) group (1)
 Link all three changes to actual numbers with halide (1)
 Consequential on answers to part(ii) 2

Correct answer referring to only two halides scores 1 mark

If ref to halogens lose second mark

[6]

7. (a) (i) $\text{Br}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons 2\text{H}^+(\text{aq}) + \text{Br}^-(\text{aq}) + \text{BrO}^-(\text{aq})$
 formulae (1)
 balancing (ignore state symbols) (1) 2
- Accept $\rightleftharpoons \text{H}^+(\text{aq}) + \text{Br}^-(\text{aq}) + \text{HBrO}(\text{aq}) / \text{BrOH}$
 $\text{H}^+(\text{aq}) + \text{BrO}^-(\text{aq}) + \text{HBr}(\text{aq})$
 If $\text{HBr} + \text{HBrO}$, H^+ must be crossed out*
- (ii) reaction is reversible/equilibrium (reaction)
 can go backward and forward/can go both ways/occurs in
 both directions 1
- Accept reversible (1)*
- (iii) bromine has been both oxidised and reduced (1)
 ↑
 must mention bromine (Br/Br₂ for first mark)
 from 0 to +1 and -1 (1) 2
- Accept Br oxidation number both increased and decreased
 /goes up and down
 Reject bromine goes to +1 and -1
 must show from 0
 Reject arguments based on OILRIG
 Incorrect identification of ox/red i.e. ox is 0 → -1*
- (iv) $\text{Cl}_2(\text{g}) + 2\text{Br}^-(\text{aq}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{Br}_2(\text{aq})$
 formulae (1)
 balancing and state symbols (1)
 second mark dependent on first unless correct but non ionic
 equation given
 $\text{Cl}_2(\text{g}) + 2\text{KBr}(\text{aq}) \rightarrow 2\text{KCl}(\text{aq}) + \text{Br}_2(\text{aq})$ 2
- Accept $\text{Br}_2(\text{l})$
 Accept multiples
 Reject $\text{Cl}_2(\text{aq})$
 Reject $\text{Br}_2(\text{g})$ $\text{Br}^2(\text{aq})$*
- (b) (i) Sulphur from +4 to +6 /4+ to 6 + /4 to 6 (1)
 Bromine from 0 to -1 (1)
 Accept name or symbol (S or Br or Br₂) 2
- Accept oxidation and reduction transposed but correct numbers
 1 (out of 2)
 Elements correctly identified but incorrect numbers
 1 (out of 2)
 Accept sulfur, sulpher, sulfer*



8. A [1]

9. (a) (i) Procedure: Only one titration carried out/ no check on accuracy of titration
 OR
 1000 cm³ volume too large to fit in titration flask (1)
 Recording: Did not record burette readings to 0.05 cm³ / 1 decimal place / sufficient precision / recording only one significant figure in a titration reading (1) 2

(ii) $4.65 \times 10^{-5} / 4.7 \times 10^{-5} / 0.0000465 / 0.000047$ (mol) 1

(iii) $2.3 \times 10^{-5} / 0.000023$
 OR candidates answer to (ii) divided by 2 1

(iv) $2.3 \times 10^{-5} / 0.000023 \text{ mol dm}^{-3}$
 OR candidates answer to (iii) 1

(b) (i) QWC
Redox as chlorine removes/gains electrons from the metal (and is reduced) (1)
 And metal gives/loses electrons to the chlorine (and is oxidised) (1)
 Redox is essential in order to score both marks
 The gain / loss of electrons can be awarded from two ionic half equations. 2

(ii) Chlorine is (highly) toxic/poisonous/irritant
 OR chlorine has an unpleasant smell (1) 1

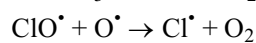
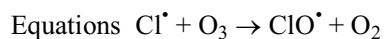
(iii) $\text{Ca}(\text{ClO})_2$ (1) 1

- (iv) QWC
 Cl is oxidised from +4 (in ClO_2) to +5 (in HClO_3) (1)
 and is reduced (from +4) to +1 (in HClO) (1) 2

(c) QWC

Any of the five points below as long as they are logically connected and use correct scientific terminology plus 1 mark for an equation to a maximum of 6 marks.

- CFCs are greenhouse gases
- because their dipole moment changes when they vibrate
- and so contribute to global warming
- depletion of the ozone layer
- causes less ozone to absorb UV radiation (from the sun) / increase in UV reaching the earth's surface
- causes skin cancer / mutations
- CFCs (decompose photolytically to) produce free radical chlorine atoms/ Cl radicals
- Recognition that one Cl radical can cause the destruction of many thousands of ozone molecules / or mention of chain reaction



Either equation or other relevant equation (1) 6

[17]

10. (a) formal charge 1
 an atom would have in a compound if ionic 1
 OR
 number of electrons lost or gained 1
 control of / used for bonding 1
- (b) (i) 0 +1 -1 (ignore everything else) 1
 (ii) One of the chlorines in each molecule (0 to +1) has lost an electron / been oxidised 1
 The other chlorine in the chlorine molecule has gained an electron / been reduced to -1 1
 a simple statement / definition of disproportionation max 1

- (c) reacts / changes / dissociates / ionises /
HCl donates a proton to the water 1
H⁺ (aq) or H₃O⁺ (aq) ions 1
- (d) white **precipitate (1)** soluble in ammonia. **(1)** chloride cream **ppte (1)**
slightly soluble in ammonia **(1)** bromide yellow **ppte (1)**
insoluble in ammonia **(1)** iodide 6
if only 3 colours without any mention of ppte max **1** out of **3** **[13]**
- 11.** (a) B **(1)** 1
- (b) Limewater turns milky ∴ CO₂ **(1)**
MgCO₃ decomposes on heating to CO₂ ∴ label correct / equation **(1)** 2
- (c) Substance on wire in flame **(1)** not burn or heat (in test tube)
(Pale) green flame for barium **(1)**
No colour for magnesium **(1)**
or
add dilute sulphuric acid **(1)**
barium hydroxide does not dissolve **(1)**
magnesium hydroxide dissolves / forms colourless solution **(1)**
or
Valid chemical test 3
- (d) (brown gas is) nitrogen dioxide **(1)**
(gas relights a glowing splint) oxygen **(1)**
 $2\text{Mg}(\text{NO}_3)_2 \rightarrow 2\text{MgO} + 4\text{NO}_2 + \text{O}_2$
species **(1)** balance **(1)** 4 **[10]**
- 12.** (a) (i) Ca brick red or orange red, Ba (apple) green **(1)** each 2
- (ii) electrons excited / promoted **(1)**
fall to lower energy level / orbital **(1)**
give out energy in the visible region / in form of light **(1)** 3
- (b) $2\text{Ba}(\text{NO}_3)_2 \rightarrow 2\text{BaO} + 4\text{NO}_2 + \text{O}_2$ **(2)**
species **(1)** balance **(1)** 2

- (c) (i) ability (of a cation) to distort / change shape of **(1)**
the electron cloud around an anion **(1)** 2
- (ii) Size /radius /ionic radius **(1)** charge **(1)** 2
- (iii) Mg^{2+} / magnesium **ion** smaller than Ba^{2+} / barium **ion**
or
 Mg^{2+} has higher charge density **(1)**
Polarising power increases/ Mg^{2+} able to polarise the nitrate
ion more effectively than Ba^{2+} **(1)**
this weakens the bonds in the nitrate / bonds in nitrate more
easily broken **(1)** 3 **[14]**
13. (a) (i) $2\text{Ca} + \text{O}_2 \rightarrow 2\text{CaO}$ **(1)** 1
- (ii) $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{NaOH}$ **(1)** 1
- (iii) $\text{Na}_2\text{O} + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O}$
Species **(1)** Balancing **(1)** 2
- (b) (Thermal stability) increases **(1)** (with some
attempt at a reason)
- (cat)ion size increases / (cat)ion charge density
decreases **(1)**
polarises or distorts carbonate ion / anion /
electron cloud less. **(1)** 3 **[7]**
14. $\text{O}^{2-} + \text{H}_2\text{O} \rightarrow 2\text{OH}^-$
IGNORE state symbols
ALLOW if Mg^{2+} shown on both sides 1 **[1]**
15. (a) (i) $\text{Ba} + 2\text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2 + \text{H}_2$
IGNORE state symbols 1
- Accept multiples*
- Reject $\text{Ba} + \text{H}_2\text{O} \rightarrow \text{BaO} + \text{H}_2$*

- (ii) $\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HCl}$
OR
 $2\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HCl}$
IGNORE state symbols 1
Accept multiples
Reject HNaSO₄
- (b) (i) Green/pale green/apple green 1
Accept yellow-green
Reject any mention of blue e.g. blue green OR any other colour
- (ii) Red 1
Accept deep/dark red / carmine/crimson /scarlet
Reject lilac
Reject any mention of lilac e.g. lilac-red OR any other colour
- (c) **Electrons** (absorb heat/energy) and are promoted to **higher** energy levels **(1)**
 as they **drop** back/down **(1)**
 Emit radiation (of characteristic colour)
OR emit light **(1)** 3
Accept “excited/go” instead of “promoted”
Accept “orbitals/shells” instead of “energy levels”
Reject if any reference to absorption spectra
e.g. light absorbed (0)
Reject (produce) colours (0)

- (d) Percentage oxygen (= 45.1) (1)
 ÷ Ar (1)
 Empirical formula = KO₂ (1)

e.g.

Percentage of oxygen = 45.1 (1)

K	O	
$\frac{54.9}{39}$	$\frac{45.1}{16}$	(1)
1.41	2.82	

KO₂ (1)

3

Accept use of atomic numbers 2 max

Accept use of "O₂" Mr ~ 32 but only if give formula KO₂ (for 3 marks)

Reject mole calculation – then inverted, no consequential marking on formula

[10]

16. (a) (i) $4\text{LiNO}_3 \rightarrow 2\text{Li}_2\text{O} + 4\text{NO}_2 + \text{O}_2$
 Species (1)
 Balance (1)
 Not stand alone conditional on correct species

2

Accept or fractions/ multiples

- (ii) $2\text{CsNO}_3 \rightarrow 2\text{CsNO}_2 + \text{O}_2$
 Correct balanced equation

1

Accept or fractions/ multiples

- (b) (i) There must be a comment about both barium and calcium to score both marks
 Barium would react to produce a (colourless)/(clear) solution does not give a ppt./ clear (1)
Allow Ba and Ca in argument
*Accept barium **hydroxide** dissolves*
Reject goes colourless
 Calcium would go cloudy /give (white) ppt. (1)
 E.g. Calcium would go cloudy but barium (goes) clear (2)

2

Reject other colours

- (ii) Insoluble/ solid/layer / coating of **barium sulphate** formed **(1)** allow equn with BaSO₄(s)
 Must say what the coating is since question says use information in table
 Which prevents **acid** getting to surface (of barium) **(1)**
 2nd mark conditional on 1st need some idea that a substance is formed that generates a barrier to further reaction 2

If candidate uses word ppt must be clear that this is on the surface of the barium or causes interference

Reject BaSO₄ unreactive

Reject barium disappears

Any reference that implies barium all used up or was a very small piece or acid not in excess or reaction over scores zero

Reject references to other layers such as oxide/hydroxide

- (c) Insoluble **(1)** 1

- (d) Ca(s) + 2H⁺(aq) → Ca²⁺(aq) + H₂(g)
 1 mark for equation
 1 mark for state symbols 2

Accept state symbol mark for correct molecular equation

*Ca(s) + 2HCl(aq) → **CaCl₂(aq)** + H₂ (g) scores (1)*

[10]

17. (a) (i) (pale) green 1

Accept apple green

Accept yellow(y) green

Reject blue green

(ii) Crimson 1

Accept red
Accept scarlet
Accept carmine
Accept depth of red colour e.g.
Dark red
Deep red
Pale red
Light red
Bright red

Reject red with any other colour e.g.
Brick-red
Orange-red
Yellow-red
Magenta

(b)

Ba	O	
<u>81.1</u>	<u>18.9</u>	
137	16	(1)
= 0.592	= 1.18	
1	2	

Accept dividing by 32 scores (0) unless their table is headed by O₂, then answer BaO₂ scores (1)

Correct working leading to answer BaO₂ (1)

but if this is the case BaO scores (0)

Working must be shown and final formula given for 2 marks

BaO₂ without working 1 mark

2

Reject any answer dividing by atomic number (0)
This leads to Ba₂O

(c) (i) $\text{Ba} + 2\text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2 + \text{H}_2$

Ignore state symbols even if they are wrong

1

Accept multiples

Reject equations based on BaO

- (ii) • Gets warm
Accept heat produced
- Effervescence/fizzing/ bubbles/mist
Accept bubbles of hydrogen
- Ba sinks/moves up and down /Does not float
Give one mark for observation from each bullet point to max of 2
- 3 answers given, one wrong scores **(1)**
 3 answers given, two wrong scores zero
- Ignore mention of Steam/steamy fumes
 Ba gets smaller
 Ba disappears
 Goes cloudy / precipitate
 Gas/hydrogen evolved is not an observation 2
- Reject reference to flame*
Reject melts
Dashes about on surface are wrong answers
- (iii) *Red litmus* (goes) blue/ “(→) blue”
and
blue litmus unchanged/stays blue/no effect/nothing 1
- [8]**

18. B [1]
19. B [1]
20. C [1]
21. D [1]
22. A [1]