1. (a) Accepts electrons 1

(b) Charge on the ion (or element or atom) 1

(c) +4 1
+5 1
-3 1

(d) (i) $Cu^{-} \rightarrow Cu^{2+} + 2e^{-}$ 1

(ii) $NO_3^- + 4H^+ 3e^- \rightarrow NO_2\, H_2O$ 1

(iii) $3Cu + 2NO_3^- + 8H^+ \rightarrow 3Cu^{2+} + 2NO + 4H_2O$ 1

[8]

5. (a) (i) Loss (of electrons) **(1)**

(ii) *Oxidation state of nitrogen in NO:* (+) 2 **(1)**

Oxidation state of nitrogen in NH^+: –3 **(1)**

(iii) I_2 **(1)** 4

(b) (i) $Cl_2 + 2e^- \rightarrow 2Cl^-$ **(1)**

(ii) $SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e^-$ **(1)**

(iii) $SO_2 + 2H_2O + Cl_2 \rightarrow SO_4^{2-} + 2Cl^- + 4H^+$ **(1)**
or H_2SO_4 + 2HCl etc
Ignore state symbols in equation
Allow multiples of all equations

3

[7]

6. (a) gains electrons **(1)** 1
or accepts/takes electrons
Allow an electron
or just 'gains'
or reduction is gain of electrons, but NOT OILRIG even if stated
Do not allow mention of electron pair(s)

(b) (i) *Oxidising agent*: Ag+ **(1)** (*or Ag I*)

Reducing agent: SO_2 **(1)** (*or S^{VI}, not sulphur*)

(ii) $SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e^-$ **(1)** (*or $H_2SO_4 + 2H^+ + 2e^-$*) 3
allow e i.e. no charge
penalise E^- once only
allow $-e^-$ on LHS

(c) (i) $Fe^{2+} \rightarrow Fe^{3+} + e^-$ **(1)**

(ii) 5 **(1)** (*or V or +5*)

(iii) $ClO_3^- + 6H^+ + 6e^- \rightarrow Cl^- + 3H_2O$ **(1)**

(iv) $ClO_3^- + 6H^+ + 6Fe^{2+} \rightarrow Cl^- + 3H_2O + 6Fe^{3+}$ **(1)** 4

[10]

(a) (i) $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$ **(1)**

(ii) $2I^- \rightarrow I_2 + 2e^-$ **(1)**

(iii) $H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$ **(1)** 3

(c) (i) $Cl_2 + 2e^- \rightarrow 2Cl^-$ **(1)**

(ii) +1 **(1)**
Allow 1, +1, Cl^+

(iii) $Cl_2 + 2H_2O \rightarrow 2HClO + 2H^+ + 2e^-$ **(1)**

(iv) kill bacteria / germs / microorganisms / bugs
allow sterilise, disinfect
Not allow purify, safe to drink

4

[12]

8. (a) Gains electrons (or removes electrons) 1

(b) (i) +4 1
+6 1

(ii) $Br_2 + 2e^- \rightarrow 2Br^-$ 1

(iii) $SO_2 + 2H_2O \rightarrow 4H^+ + SO_4^{2-} + 2e^-$ 1

(iv) $Br_2 + SO_2 + 2H_2O \rightarrow 2Br^- + 4H^+ + SO_4^{2-}$ 1

(c) $Cl_2 + H_2O \rightarrow H^+ + Cl^- + HOCl$ 1
Chloride: –1 1
Chlorate(I): +1 1

(d) Chloride ions cannot reduce sulphuric acid 1
(Or chloride ions are weak reducing agents
Or sulphuric acid is not a strong enough oxidising agent
Or sulphuric acid is a weaker oxidising agent than chlorine)

(e) $KCl + H_2SO_4 \rightarrow HCl + KHSO_4$ 1
(Allow $2KCl + H_2SO_4 \rightarrow 2HCl + K_2SO_4$*)*

(f) (i) Bromine 1

(ii) Sulphur dioxide 1

[13]

9. (a) Increase 1
Van der Waal's forces between molecules 1
Increase with size (or M_r or surface area etc) 1
More energy needed to break (overcome) these forces 1
(Note max 2 from last three marks if no mention of molecules or 'molecular')

(b) (i) Brown solution (or yellow or orange) 1
$Cl_2 + 2Br \rightarrow 2C1^- + Br_2$ 1

(ii) cream precipitate 1
$Br^- + Ag^+ \rightarrow AgBr$ 1
Precipitate dissolves 1

(iii) orange (brown) fumes (gas), White fumes (or misty fumes), choking gas (any 2) 2

(c) $2H^+ + H_2SO_4 + 2Br^- \rightarrow SO_2 + Br_2 + 2H_2O$ (SO_2 and Br_2 (1), equation (1)) 2

[13]

10. (a) increases from fluorine to iodine **(1)**

sizes of molecules increase **(1)**
(or molecules have more electrons or mass of molecules increases)
QoL mark

Magnitude of intermolecular forces or vdW forces increase **(1)** (or more vdW forces)

More energy required to separate molecules (or particles) **(1)** 4
(or more energy to break intermolecular forces)
or intermolecular forces difficult to break

(b) with NaCl white ppt **(1)**
soluble in ammonia **(1)**
note, if ppt clearly refers to wrong substance e.g. NaCl then C.E = 0

with NaBr cream (or off white or biege) ppt **(1)**
partially soluble (or insoluble) in ammonia **(1)** 4
ignore references to conc ammonia
if obviously added silver nitrate mixed with ammonia allow:
*NaCl: no change **(2)***
*NaBr: cream ppt **(2)***

(c) oxidising ability decreases from chlorine to iodine (or down the Group) **(1)**

$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$ **(1)**
allow use of NaBr, HBr etc

Br_2 red brown (or yellow or orange) liquid (or solution but not solid) **(1)**

$Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$ **(1)**
allow use of NaBr etc, penalise HI once only

I_2 brown solution / black solid **(1)**
do not allow any reference to purple

$Br_2 + 2I^- \rightarrow 2Br- + I_2$ **(1)**

Yellow/orange/red-brown/brown solution goes brown/darker brown solution/ black solid **(1)** 7

[15]

11. (a) Reduction involves gain of electrons 1

A reducing agent loses (donates) electrons 1

(b) (i) Sulphur dioxide 1
oxidation state +4 1
Sulphur 1
oxidation state 0 1
Hydrogen sulphide 1
oxidation state – 2 1

(ii) Sulphur dioxide is a choking gas or has a pungent odour
Sulphur is a yellow solid 1
Hydrogen sulphide has a smell of bad eggs 1
Any 2 marks

(iii) $SO_4^{2-} + 4H^+ + 2e^- \rightarrow SO_2 + 2H_2O$ 1
$SO_4^{2-} + 8H^+ + 6e^- \rightarrow S + 4H_2O$ 1
$SO_4^{2-} + 10H^+ + 8e^- \rightarrow H_2S + 4H_2O$
Any 2 marks
(Allow equations with H_2SO_4)

(c) $Cl_2 + H_2O \rightarrow H^+ + Cl^- + HOCl$
or $Cl_2 + H_2O \rightarrow 2H^+ + Cl^- + OCl^-$
or $Cl_2 + H_2O \rightarrow HCl + HOCl$

Water is not oxidised
The oxidation states of O (–2) and H(+1) remain unchanged 3

[15]

12. (a) decreases 1
number of shells increases/ shielding increases /atomic size increases 1
weaker attraction (by nucleus) on bonding electrons / weaker attraction (by nucleus)
on electron pair in a covalent bond 1

(b) (i) increases 1

(ii) concentrated sulphuric acid 1

(c) white ppt 1
soluble in ammonia 1
cream ppt 1
partially soluble /insoluble in ammonia 1

(d) $Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$ 1
bleach 1
disinfectant /steriliser/kills bacteria 1

[12]

13. (a) Fluorine or F_2 or F **(1)** 1
NOT Fl

(b) I^- (or At^-) **(1)** 1
allow $+e^-$ but not equation

(c) *Observation with NaF(aq):* no change OR colourless solution
OR remains colourless **(1)**

Observation with NaI (aq): yellow solid / percipitate **(1)**

Equation: $I^-(aq) + Ag^+(aq) \rightarrow AgI(s)$ **(1)** 3
or $NaI\ (aq) + AgNO_3\ (aq) \rightarrow NaNO_3(aq) + AgI(s)$
no ss no marks

(d) *Observation*: steamy / white / misty fumes **(1)**
NOT smoke / gas

Equation: $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$ 2
Ignore ss

(e) *Observation 1*: black / grey solid
lilac / purple gas
pungent / steamy / choking fumes / steam

Observation 2: yellow solid / smell <u>bad</u> eggs / stink bombs **(2)**
any two mark first one on each line

Equation: $2NaI + 2H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + I_2 + SO_2$
two reduction products from Na_2SO_4 e.g. H_2S or S or $SO_2 + I_2(s)$ **(1)** 4
*balanced equation **(1)***

(f) *Observation*: (Starts) blue or black **(1)** <u>$\rightarrow$ colourless</u> **(1)**

Equation: $I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$ **(1)** 3
(or $I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$)

[14]

14. (a) decreases; 1
increase in shielding ; 1
(or atomic radius)
less attraction for bonding *(or shared)* electrons; 1

(b) brown solution; 1
(or black solid)
$Cl_2 + 2KI \rightarrow 2KCl + I_2$; 1
(or ionic equation)

(c) SO_2; 1
$SO_4^{2} + 4H^+ \, 2e^- \rightarrow SO_2 + 2H_2O$; 1
S (also H_2S); 1
$SO_4^{-2} + 8H^+ \, 6e^- \rightarrow S + 4H_2O$ (or $SO_4^{2-} + 10H^+ + 6e^- \rightarrow H_2S + 4H_2O$; 1

(d) $Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$; 1
sodium chloride; 1
–1; 1
sodium chlorate(I) (or bleach etc); 1
+1; 1

[14]

16. (a) *Trend*: decrease **(1) C.E if wrong**
Explanation: number of shells increases (or atomic radius increases) **(1)**
increased nuclear shielding **(1)**
or less attraction for bond (pair electrons)

3

17. (a) (i) –2 OR 2–

(ii) NaI or NaAt or I^- or iodide or At^-or Astatide **(1)**
<u>Not</u> atoms or molecules

(iii) Smell of bad eggs **(1)**
Allow $PbAc_2$ goes black and $K_2Cr_2O_7/H^+$ goes cloudy green

(iv) $8\,e^- + 8\,H^+ + H_2SO_4 \rightarrow H_2S + 4H_2O$ **(1)**
OR $10\,H^+ + SO_4^{2-}$

4

(b) (i) HF or HCl **(1)**

CE = 0 if redox answer given

If wrong halide given allow max one in b(iii)

If NaF or NaCl, or F^- or Cl^- given lose mark in (i)

Mark on if X is e.g. HF_2 or H_2F

(ii) NaF or NaCl or F^- or Cl^- **(1)**

(iii) A proton donor or an acid **(1)**

(iv) $H^+ + F^- \rightarrow HF$

OR $H_2SO_4 + NaF \rightarrow NaHSO_4 + HF$

OR $H_2SO_4 + 2\ NaF \rightarrow Na_2SO_4 + 2\ HF$

OR for chloride

4

[8]

18. (a) decreases **(1)**

attraction for bonding pair goes down **(1)**

or electron density in bond, or covalent (or bonding) electrons

as size of atoms or shielding goes up **(1)** 3

(b) (i) Br_2 **(1)**

formulae <u>not</u> names, gases <u>or</u> fumes, <u>not</u> solutions

brown fumes **(1)**

<u>or</u> yellow–brown <u>or</u> orange, <u>not</u> yellow

I_2 **(1)**

violet fumes or black solid **(1)**

<u>or</u> purple fumes

(ii) SO_2 **(1)** S **(1)** H_2S **(1)**
S <u>and</u> H_2S **(1)**

Penalise missing S once only

(iii) HBr **(1)** HI **(1)** (<u>not</u> steam)

name <u>or</u> formula
penalise wrong state symbols <u>once</u> only

acid–base <u>or</u> displacement **(1)** 11

[14]

19. (i) ionisation energy decreases down group **(1)**
radius or shielding increases **(1)**

electronegativity decreases down group **(1)**
radius or shielding increases **(1)**
attraction for electron pair in covalent bond decreases **(1)**

(ii) $BeCl_2$ is covalent **(1)**
Be(OH)2 is amphoteric **(1)**
dissolves in excess NaOH **(1)**
forming $[Be(OH)4]^{2-}$ ions **(1)**
Be^{2+} ion has high charge to size ratio **(1)**
polarises anions **(1)**

max 10

[10]

20. (a) (i) HNO_3 or CH_3COOH **(1)**
CE in (a) if incorrect acid given

(ii) $2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + CO_2 + H_2O$ **(1)** 2

(b) (i) I^- or At^- not elements, atoms or molecules **(1)**

(ii) F^- not elements, atoms or molecules **(1)** 2

(c) (i) Cl^- **(1)**
Allow AgCl Not element, atoms or molecules

(ii) Br^- **(1)**
Allow AgBr Not element, atoms or molecules

2

[6]

21. (a) Chlorine added to bromide

Yellow/orange solution (or colour) but not precipitate or gas formed **(1)**

Allow:- orange or yellow-brown ; yellow-red; orange-brown; orange-red but NOT red or brown

$2Br^- + Cl_2 \rightarrow 2Cl^- + Br_2$ **(1)**

Allow molecular equations; allow equations with KBr; ignore state symbols

Chlorine added to iodide

Brown solution (or colour) or black or grey or purple/black precipitate **(1)**

Do not allow purple solution or purple fumes or brown precipitate

$2I^- + Cl_2 \rightarrow 2Cl^- + I_2$ **(1)** 4

Allow molecular equations; allow equations with KI; ignore state symbols

(b) **Concentrated sulphuric acid added to a bromide**

If aqueous sulphuric acid used, or Conc H_2SO_4 (aq), in any section, do not allow marks for observations in that section.

Orange or brown or yellow or yellow-red (or these colours-combined) fumes/gas**(1)**

Do not allow red on its own

Steamy or white fumes or misty **(1)**

Stated reduction product;- SO_2 *(wrong if extra product(s) given)*

Concentrated sulphuric acid added to an iodide

Purple fume or black solid **(1)**

Steamy or white fumes or misty **(1)**

Yellow (solid) **(1)**

Smell of bad eggs **(1)**

Stated reduction products;- SO_2, S, H_2S *(all three must be given)* **(1)**

Do not extract these products from equations; wrong if extra product(s) given

Half-equations

Ignore state symbols in equations

$2Br^- \rightarrow Br_2 + 2e^-$ **(1)**

$4H^+ + SO_4^{2-} + 2e^- \rightarrow SO_2 + 2H_2O$ **(1)**

or $2H^+ + H_2SO_4 + 2e^- \rightarrow SO_2 + 2H_2O$

Overall equation

$4H^+ + SO_4^{2-} + 2Br^- \rightarrow SO_2 + 2H_2O + Br_2$ **(1)**

or $2H^+ + H_2SO_4 + 2Br^- \rightarrow SO_2 + 2H_2O + Br_2$ 9

[13]

24. Addition of silver nitrate

No precipitate with fluoride ions **(1)**
White precipitate with chloride ions **(1)**
Cream precipitate with bromides ions **(1)**
Yellow precipitate with iodide ions **(1)**

Addition of ammonia solution

AgCl precipitate dissolves in dilute NH3 (aq) **(1)**
AgBr precipitate sparingly soluble in dilute NH3 (aq)
OR soluble in concentrated NH3 (aq) **(1)**

AgL precipitate insoluble in concentrated NH3 (aq) **(1)** 7

Silver astatide

AgAt precipitate insoluble in concentrated NH3 (aq) **(1)**
Solubility of AgX decreases down Group VII
OR as AGI insoluble predict AgAt insoluble **(1)**

2

[9]

25. (a) Oxidising power decreases, $Cl_2 > Br_2 > J_2$ **(1)** 1

(b) Observation with aqueous KC1 Yellow solution or no reaction **(1)**

Observation with aqueous KI Brown solution or black precipitate **(1)**

Ionic equation $2I^- + Br_2 \longrightarrow 2Br^- + I_2$ **(1)** 3

(c) (i) Cl_2 **(1)**

(ii) $H_2O + Cl_2 \rightleftharpoons HCl + HClO$ **(1)**

(iii) Red colour due to presence of acid or H^+ ions **(1)**

White due to bleading by HClO **(1)** 4

(d) $2NaOH + Cl_2 \longrightarrow NaCl + NaClO + H_2O$ **(1)** 1

[9]

26. (a) (i) **A** = calcium iodide / CaI_2 / any calcium **(1)**

B = silver iodide / AgI only **(1)**

C = iodine / I_2 only **(1)**

D = sodium thiosulphate / $Na_2S_2O_3$ only **(1)** 4

(ii) $2AgNO_3 + CaI_2 \longrightarrow 2AgI + Ca(NO_3)_2$

or $Ag^+ + I^- \longrightarrow AgI$ **(1)** 1

allow equation consequential on identity of **A** in (i)
allow any Ca/Sr/Li halide

(b) (i) two factors hydration energy / explanations in terms of hydration **(1)**
lattice energy / explanations in terms of breaking down lattice **(1)**

explanation hydration energy of Ba^{2+} is smaller than Mg^{2+} / insufficient hydration energy to overcome lattice energy for $BaSO_4$ **(1)** 3

(ii) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

for ionic equation **(1)**

for state symbols (may be awarded from a molecular equation) **(1)** 2

(c) (i) $NaCl + H_2SO_4 \rightarrow HCl + NaHSO_4$ **(1)** 1

allow Na_2SO_4 with correct balancing

(ii) compound SO_2 only **(1)**

oxidation state +4 **(1)** 2

must have + sign before or Roman numeral
allow this mark mark consequentially on H_2S, H_2SO_3 , but not S, SO_3

(iii) $2HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$

all formulae correct **(1)**

correctly balanced **(1)** 2

allow H_2SO_3

(iv) any brown / orange / red / steamy fumes / white fumes / choking smell /froth **(1)** 1

[16]

27. (a) a substance which accepts electrons / removes electrons (from another substance) **(1)**

not just removal of electrons 1

(b) decreasing trend in oxidising power **(1)**

halogen atoms become larger / have more shells / more shielding **(1)**

less attraction for electrons **not** lower electronegativity **(1)**

allow reverse argument for I→F 3

(c) (i) KI(aq) colourless **and** Cl_2(aq) colourless/green / yellow green / yellow **(1)**

yellow / orange / brown (solution) / black (precipitate) **(1)**
not clear, **not** purple

if yellow given for Cl_2 (aq), must be darker colour for mixture 2

(ii) $2KI + Cl_2 \rightarrow 2KCl + I_2$
or $KI + ½\ Cl_2 \rightarrow KCl + ½I_2$
or $I^- + ½\ Cl_2 \rightarrow Cl^- + ½\ I_2$
or $2I^- + Cl_2 \rightarrow 2Cl^- + I_2$ **(1)**

not an equation with ClO^- 1

(iii) iodide / I^- / KI / potassium iodide **(1)** 1

(iv) $½Cl_2 + e^- \rightarrow Cl^-$
or $Cl_2 + 2e^- \rightarrow 2Cl^-$ **(1)**

$I^- \rightarrow ½\ I_2 + e^-$
or $2I^- \rightarrow I_2 + 2e^-$ **(1)**

allow 1 mark for oxidising and reducing in wrong spaces 2

(d) (i) oxidation number of iodine in IO_3^- = V / +5 **(1)**

oxidation number of iodine in I^- = –1 **(1)**

oxidation number of iodine in I_2 = 0 **(1)**

penalise 5+ and 1– once; penalise twice if 5 and 1 given 3

(ii) $IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

all species present (ignore electrons) **(1)**
balanced **(1)**

allow $KIO_3 \equiv IO_3^-$ and $KI \equiv I_2$ for species mark
if K included, K^+ must appear on r.h.s. for balanced mark
similarly for H_2SO_4 / HCl instead of H^+ 2

[15]

28. (a) Increase in boiling temperature:–
Molecular size increases from F_2 to I_2 **(1)**
van der Waals attractive forces increase **(1)** 2

(b) Reducing power increases from F^- to At^- **(1)**
Ionic size increase **(1)**
Outer electrons further from the nucleus/more shielded **(1)**
Less strongly attracted/ more easily lost. **(1)** 4

(c) HAt (g) **(1)**
Astatide a base/proton acceptor **(1)**
$NaAt + H_2SO_4 \rightarrow NaHSO_4 + HAt$ **(1)**

$SO_2(g)$ **(1)**

Astatide a reducing agent **(1)**

$2At^- \rightarrow At_2 + 2e^-$ **(1)**

$H_2SO_4 + 2H^+ + 2e^- \rightarrow SO_2 + 2H_2O$ **(1)**

or $2NaAt + 2H_2SO_4 \rightarrow SO_2 + At_2 + 2H_2O + Na_2SO_4$ **(2)**

$H_2S(g)$ **(1)**

Astatide a reducing agent **(1)**

$8At^- \rightarrow 4At_2 + 8e^-$ **(1)**

or $H_2SO_4 + 8H^+ + 8e^- \rightarrow H_2S + 4H_2O$ **(1)**

$8NaAt + 5H_2SO_4 \rightarrow H_2S + 4At_2 + 4H_2O + 4Na_2SO_4$ [2] Max 9

[15]

29. (a) Decreases **(1)**

Atomic radius / size increase or atom has more shells more shielding or more shells (if not given above) **(1)**

less attraction for shared electron pair or electrons / electron density / electron pair in a covalent bond **(1)** 4

If wrong trend given allow max [2] for At. Rad. increases (1) shells/shielding increases

(b) Increases **(1)**

Molecular size increases / molicules have more electrons / molecules have more shells / larger molecular mass **(1)**

Increase in intermolecular forces / van der Waal forces / v.d.w. explained **(1)**

Mark CE if trend incorrect. Mark explanation points separately

Note: In part (a) mark CE if ions or molecules discussed AFTER a correct trend mark awarded.

3

[7]

30. (a) (i) ability of an <u>atom to withdraw electrons</u> **(1)** from a <u>covalent bond</u> **(1)**

(ii) attraction for electron pair goes down as size of atoms <u>or</u> shielding goes up **(1)** 3

(b) *Effect on bond polarity* None **(1)**

*Explanatio*n equal and opposite effect from each atom cancels out **(1)** 2

(c) (i) SO_2 **(1)**

SO_2 **(1)** H_2S **(1)**

(ii) Br_2 **(1)** brown fumes **(1)**

I_2 violet/purple fumes **(1)**

HBr and HI **(1)** steamy fumes **(1)** 9

[14]

31. (a) (i) SO_2 **(1)**

(ii) H_2S **(1)** 2

(b) (i) $Hl \rightarrow ½\ l_2 + H^+ + e^-$ **(1)**

(ii) $8H^+ + H_2SO_4 + 8e^- \rightarrow H_2S + 4H_2O$ **(1)**

(iii) $2H^+ + H_2SO_4 + 2e^- \rightarrow SO_2 + 2H_2O$ **(1)**

(iv) $lOHI + 2H_2SO_4 \rightarrow H_2S + SO_2 + 5I_2 + 6H_2O$

components **(1)** balance **(1)** 5

(c) *Equation* $2OH^- + Cl_2 \rightarrow OCl^- + Cl^- + H_2O$ **(1)**

Commercial use OCl^- is a bleach/disinfectant **(1)** 2

[9]

32. (a) (i) oxidation power increases **(1)**
more shells added **(1)**
atomic radius increase **(1)**
attraction for outer electrons decrease **(1)**

(ii) $NaCl + Cl_2$ no observable change **(1)**
$NaBr + Cl_2$ orange/yellow solution formed **(1)** of bromine **(1)**
$NaI + Cl_2$ red/brown solution formed or black precipitate **(1)** of iodine **(1)**

Equations $2NaBr + Cl_2 \rightarrow 2NaCl + Br_2$ Reagents **(1)**; balance **(1)**
$2NaI + Cl_2 \rightarrow 2NaCl + I_2$ Reagents **(1)**; balance **(1)**

13

(b) (i) $ClO^- + 2I^- + 2H^+ \rightarrow I_2 + Cl^- + H_2O$ Reagents **(1)**; balance **(1)**
$I2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ Reagents **(1)**; balance **(1)**

Starch indicator **(1)** End-point:- Blue **(1)** to colourless **(1)**

(ii) mol thio = $23.0 \times 10^{-3} \times 0.100$ **(1)** = 2.3×10^{-3}
mol I_2 = mol thio/2 **(1)**
= 1.15×10^{-3} **(1)**

mol ClO^- in 25 cm^3 diluted solution = mol I_2 **(1)**
= 1.15×10^{-3} **(1)**

mol ClO^- in 250cm^3 diluted solution = $10 \times 1.15 \times 10^{-3}$ **(1)**
= 1.15×10^{-2} **(1)**

mol ClO^- in original 10 cm^3 solution = 1.15×10^{-2} **(1)**

Multiply by 100 to convert 10 cm^3 to 1.0 dm^3 **(1)**
Hence mol dm^{-3} = $100 \times 1.15 \times 10^{-2}$
= 1.15 **(1)** 17

[30]

33. (a) $Cl_2(aq)$ to $Br^-(aq)$; yellow-orange or yellow-red or yellow-brown solution **(1)**

$2Br^- + Cl_2 \rightarrow 2Cl^- + Br_2$ **(1)**

or molecular equation

$C1_2(aq)$ to $I^-(aq)$; brown/black solution formed or black/brown/grey ppt/solid **(1)**

$2I^- + Cl_2 \rightarrow 2Cl^- + 1_2$ **(1)**

or molecular equation4

4

(b) Bromide:- Brown/orange fumes **(1)**

Bromine produced **(1)**

Sulphur dioxide produced **(1)**

3

Iodide:- Purple fumes or black/brown/grey solid or smell of bad eggs **(1)**

Iodine produced **(1)**

SO_2, S, H_2S produced (one mark each) **(3)**

5

Half-equations	$2Br^- \rightarrow Br_2 + 2e^-$ **OR**		
	$2I^- \rightarrow I_2 + 2e^-$ **(1)**		
	$H_2SO_4 + 2e^- + 2H^+ \rightarrow SO_2$	$+2H_2O$ **OR**	
	$H_2SO_4 + 6e^- + 6H^+ \rightarrow S$	$+4H_2O$ **OR**	
	$H_2SO_4 + 8e^- + 8H^+ \rightarrow H_2S$	$+4H_2O$ **(1)**	
Overall equation	Any correct equation based on half-equations **(1)**		

3

[15]

34. (a) (i) Increase from F_2 to I_2 **(1)**

(ii) Intermolecular (van der Waals) forces increase **(1)**
as Mr/molec radius/No of electron shells increases **(1)**

(iii) Cl_2 = gas, Br_2 = liquid, I_2 = solid **(1)**

$\therefore$ Astatine = solid **(1)** 5

(b) (i) electron donor **(1)**

(ii) increases down group **(1)**
increased shielding/increased ionic radius
more shells makes e^- easier to lose **(1)**

(iii) Br^- reduces S from oxidation state +6 **(1)**
to oxidation state +4 (SO_2) **(1)**

I^-, in addition, gives oxidation state +O (S) **(1)**
and oxidation state –2 (H_2S) **(1)** 7

(c) (i) $Cl_2 + 2OH^- \rightleftharpoons Cl^- + OCl^- + H_2O$ **(1)**

(ii) Cl_2 has oxidation state 0 **(1)**
Cl^- has oxidation state –1 **(1)**
$OC1^-$ has oxidation state +1 **(1)**

(iii) Oxidising agent in forward direction Cl_2 **(1)**
Reducing agent in backward direction Cl^- **(1)** 6

[18]

35. (a) Decreases **(1)**

Atomic radius increases **(1)**

due to more shells or due to more shielding **(1)** 3

(b) Increases **(1)**

Molecular size or surface area increases **(1)**

Intermolecular van der Waals' forces increase **(1)** 3

(c) Br_2 in non-polar or atoms have same electronegativity **(1)**

weak van der Waals' forces between Br_2 molecules **(1)**

I-C1 is polar or atoms have different electronegativies **(1)**

Dipole-dipole attractive forces between ICl molecules **(1)** 4

[10]

36. Br^- present because orange – brown fumes of bromine liberated **(1)**

$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$ **(1)**

I^- present because black precipitate of iodine formed **(1)**

$Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$ **(1)**

AgI precipitate insoluble in concentrated ammonia **(1)**

AgBr precipitate soluble in concentrated ammonia **(1)**

Moles AgI = mass/M_r = 0.564/235 **(1)**; $= 2.4 \times 10^{-3}$

Mass I^- = mole AgI × A_r = $2.4 \times 10^{-3} \times 127$ **(1)** = 0.305g

Hence mass AgBr = 0.902 – 0.564 = 0.338g **(1)**

Moles AgBr = mass/M_r = 0.338/188 **(1)** $= 1.8 \times 10^{-3}$

Mass Br^- = Mole x A_r = $1.8 \times 10^{-3} \times 80$ **(1)** = 0.144g

Percentage Br^- in sample = 0.144 × 100/0.545 = 26.4% (26 – 27) **(1)**

Percentage I^- in sample = 0.305 × 100/0.545 = 55.96% (56 ± 0.5) **(1)**

Equation marks

$Ag^+ + I^- \rightarrow AgI$ **(1)**

$Ag^+ + Br^- \rightarrow AgBr$ **(1)**

$AgBr + 2NH_3 \rightarrow [Ag(NH_3)_2]^+ + Br^-$ **(1)**

[Max 15]

37. (a) A reagent which takes or accepts electrons **(1)** 1

(b) Mn has been reduced from VII to IV **(1)**
Mn has been reduced from VII to VI **(1)**
Oxygen has been oxidised from –2 to zero **(1)** 3

(c) (i) $Cl_2 + H_2O \rightleftharpoons 2H^+ + ClO^- + Cl^-$ **(1)**

(ii) OH^- removes H^+ **(1)** displacing equilibrium to the right **(1)**
$H^+ + OH^- \rightarrow H_2O$ **(1)**
or $C1_2 + 2NaOH \rightarrow NaClO + NaCl + H_2O$ 4

[8]

38.

(b) Addition of silver nitrate
Chloride gives white precipitate / solid **(1)**
Bromide gives cream precipitate / solid **(1)**
Iodide gives yellow precipitate / solid **(1)**
Addition of ammonia
Chloride precipitate soluble in dilute **(1)**
Bromide precipitate soluble in concentrated **(1)**
Iodide precipitate insoluble **(1)**
Do not allow halogen or sodium halide

6

[15]

40. (i) Hydroxide solubility increases *(need <u>trend</u>)* 1
Sulphate solubility decreases *(need <u>trend</u>)* 1
(If <u>both</u> Mg/Ba salts correctly compared - but no trend- allow 1 max)

Add acid name/correct formula HC1 1

(ii) *(accept HNO_3/CH_3COOH)* *[NOT hydrogen chloride]*
[If acid added is H_2SO_4 = CE – allow only M2]

Add Ba^{2+} salt name/correct formula $BaCl_2$ 1
(accept $Ba(NO_3)_2$ / $Ba(CH_3COO)_2$)
[If reagent added is $BaSO_4$ /Ba/$Ba(OH)_2$ = CE – allow only M1]

$MgCl_2$ No change / no ppt / no reaction 1
$MgSO_4$ White ppt / solid / suspension *[NOT chalky, milky]* 1
Both observations tied to Ba^{2+} ions being added

$MgSO_4 + BaCl_2 \rightarrow BaSO_4 + MgCl_2$ 1
Accept ionic equation

(Reagent mark (M2) can be awarded from full equation) 1

[Treat incorrect equation for $MgCl_2$ as contradiction of correct equation] 1
(Ignore carbonate equations) *(Ignore state symbols)*

(iii) Reactivity increases (down group) *[NOT solubility increases]* 1

$Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$ 1

[11]

41. Tendency **or** strength **or** ability **or** power of an <u>atom</u>/<u>element</u>/<u>nucleus</u> to attract/withdraw electron<u>s</u> / e^- density / bonding pair / shared pair 1

In a <u>covalent</u> bond 1
(tied to M1 – unless silly slip in M1)
(If molecule/ion then = CE = 0) (NOT electron (singular) for M1)
Mark as 2 + 2

Increase in size **or** number of shells **or** increased shielding **or** bonding electrons further from nucleus 1
[NOT 'increase in number of electrons']

Decreased attraction for (bonding) <u>electrons</u> 1
(tied to M3)
(If 'ion' here, lose M3 and M4) (NOT 'attraction of covalent bond')
(Ignore reference to proton number or effective nuclear charge)

[4]

42. (a) Increases 1

Heat or steam or gas phase or H temp (>100º) *(NOT 'hot')* 1

$Mg + H_2O \rightarrow MgO + H_2$ 1

(Ignore state symbols – even if they are wrong)

(b) White precipitate/solid/suspension (Not 'cloudy / milky') 1

$BeCl_2 + 2NaOH \rightarrow Be(OH)_2 + 2NaCl$

Or $Be^{2+} + 2OH^- \rightarrow Be(OH)_2$ 1

(Accept $BeCl_2 + 2OH^- \rightarrow Be(OH)_2 + 2Cl^-$)

Ppt (re)dissolves or solution goes clear 1

(Allow 'ppt disappears')

(NOT 'solution forms')

$Be(OH)_2 + 2OH^- \rightarrow Be(OH)_4^{2-}$

[NOT $Be(OH)_6^{4-}$]

Or $Be(OH)_2 + 2NaOH \rightarrow Na_2Be(OH)_4$ 1

[7]

44. (a) Barium dissolves **(1)** (or forms solution
Gas evolved **(1)** (or hydrogen evolved) or
bubbles gets hot **(1)**

do not allow evolution of wrong gas

$Ba(s) + 2H_2O(l) \rightarrow Ba^{2+}(aq) + 2OH^-(aq)$ (or $Ba(OH)_2(aq) + H_2(g)$
Species all correct **(1)**
State symbols correct **(1)** (provided species are correct)
Balanced equation **(1)**

White precipitate with sodium sulphate **(1)**
(or white solid or suspension or white cloudy or milky)
$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$
(or $Ba(OH)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaOH(aq)$
State symbols **(1)**
Balanced equation **(1)**

(mark obs. of ppts independently (and in (b))

8

(b) with $BeCl_2$ and NaOH get a white precipitate **(1)** (or solid etc)
because $Be(OH)_2$ is insoluble **(1)** (or white ppt is $Be(OH)_2$)
ppt is soluble in excess reagent **(1)**
Because $Be(OH)_2$ is amphoteric (or beryllium forms complex ion $(Be(OH)_4)^{2-}$) **(1)**
(This is the quality of language mark so the terms must be used in a sentence)

With $MgCl_2$ get white ppt **(1)**
Because $Mg(OH)_2$ is sparingly soluble (or insoluble) **(1)** (or white ppt is $Mg(OH)_2$)

With $BaCl_2$ no ppt formed **(1)** (or no reaction) (or remains in solution)
Because $Ba(OH)_2$ is soluble **(1)** (or all species are soluble)
Solubility of hydroxides increases down Group **(1)**

Note can take marks for $Be(OH)_2(s)$, $Mg(OH)_2$ (s), $Ba(OH)_2(aq)$ from equations
Wrong formula for $M(OH)_2$ loses mark

max 8

(c) (i) %O = 55.75% **(1)**

Ca : S : O : H = $\frac{23.29}{40.1} : \frac{18.64}{32.1} : \frac{55.75}{16} : \frac{2.32}{1}$ **(1)**

Allow 40, 32

= 1: 1: 6:

therefore formula: $CaSO_6H_4$ **(1)**

if Oxygen omitted can score 2nd mark only

(ii) $\frac{\text{molecular formula}}{\text{empirical formula}}$ = an integer **(1) (or a number)**

Allow correct definitions as an alternative for the mark
emp. form. The simplest ratio of atoms of each element in a compound molec. form. The actual number of atoms of each element in a molecule

Mr **(1)** (or molar mass or RFM NOT molecular mass) 5

[21]

45.

(a) (i) any two of::
effervescence / fizzing / bubbling / white precipitate or sediment / solution gets warm / metal dissolves or disappears **(2)** 2

(ii) comparisons needed for the two observations given in (a) (i)
more (rapid) effervescence / more vigorous reaction /
less or no (white) precipitate / solution gets hot i.e. hotter than in (i) /
metal dissolves more quickly **(2)** 2

(iii) $Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$ **(1)** 1

(b) (i) starch **(1)** 1

(ii) when the solution is coloured (pale) yellow / straw / close to the end point
independent of (c)(i) 1

(iii) blue / black, allow purple, ignore brown **(1)**
to colourless **not** clear **(1)**
allow 1 mark if reversed 2

(iv) ClO–: (+)1 Cl–: –1 [condone ClO–: 1+ and Cl–: 1–] **(1)** 1

(v) I^-: –1 I_2: 0 [condone 1- for I^-] **(1)** 1

(vi) $ClO^- + 2H^+ + 2I^- \longrightarrow Cl^- + I_2 + H_2O$ **(1)** 1

not KI

allow spectator K_+ ions if on both sides

[12]

46. *Q.L. = quality of language marks*

(a) **Aluminium**:

(high) melting point immediate between Si & P **(1)**

metallic bonding **(1)**

Q.L.

<u>delocalised</u> electrons mentioned in a sentence explaining metallic bonding **(1)**

energy required to break bonds **(1)**

Note: last mark note scored if there is a contradiction e.g ionic bonding or molecules or v.d.w. forces

Silicon

highest melting point **(1)**

covalent **(1)**

macromolecular **(1)** (or giant structure)

much energy needed to break bonds **(1)** (or difficult to break bonds)

Phosphorus

lowest melting point **(1)**

molecular **(1)** (or P_4)

v d W forces between molecules **(1)**

easily broken **(1)** (or not much energy required to break bonds) 12

(b) Al good conductor **(1)**

delocalised electrons **(1)** (or 'sea of' or 'free' electrons)

Si, P_4 non-conductors **(1)** (i.e Si and or P; if one wrong loses mark)

Electrons localised **(1)** (or no free electrons or no free charged particles)

(can score for Si or for P)

4

(c) Mg reacts with steam **(1)** (or water vapour)

$Mg+H_2O \rightarrow MgO+H_2$ **(1)**
(can score this mark if water not steam given)

white solid **(1)** (or Mg glows)
(can only score if steam given)

Ca reacts with (cold) water faster than Mg **(1)**

$Ca+2H_2O \rightarrow Ca(OH)_2+H_2$ **(1)**

gas bubbles **(1)** (or fizz) NOT hydrogen produced

Product dissolves (or forms a (white or ppt or cloudy) solid) **(1)**

(or Ca dissolves) 7

(d) *Q.L.*

$Be(OH)_2$ amphoteric **(1)** (must mention beryllium hydroxide not just Be) 1

dissolves in acid and alkali (base) **(1)** (or react with (or acts as) an acid & alkali)

$Be(OH)_2 + 2H^+ \rightarrow Be^{2+}+2H_2O$ **(1)** (or $Be(OH)_2+2HCl \rightarrow BeCl_2+2H_2O$ etc)

$Be(OH)_2 + 2H^+ \rightarrow Be(OH)_4^{2-}$ (1) (or $Be(OH)_2 + 2NaOH \rightarrow 2N_a^+ + Be(OH)_4^{2-}$ etc)

magnesium hydroxide basic **(1)** (or GpII hydroxides basic)

soluble in acid **(1)** (or reacts with acid)

$Mg(OH)_2+2H^+ \rightarrow Mg^{2+}+2H_2O$ **(1)** (or $Mg(OH)_2+2HCl \rightarrow MgCl_2+2H_2O$)

insoluble in base **(1)** (or does not react with NaOH/base) max 6

[30]

48. (i) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ **(1)** 1

(ii) valency / outer electrons or 2 4s electrons **(1)**

are delocalised / sea of electrons **(1)**

(within lattice) of positive ions **(1)**

(marks 2 and 3 could be in diagram)

attraction between the positive ions and delocalised electrons **(1)**
(give even if nuclei or +ve atoms) 4

[5]