

1. (a) Accepts electrons 1
- (b) Charge on the ion (or element or atom) 1
- (c) +4 1
+5 1
-3 1
- (d) (i) $\text{Cu}^- \rightarrow \text{Cu}^{2+} + 2\text{e}^-$ 1
(ii) $\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{NO}_2 + \text{H}_2\text{O}$ 1
(iii) $3\text{Cu} + 2\text{NO}_3^- + 8\text{H}^+ \rightarrow 3\text{Cu}^{2+} + 2\text{NO} + 4\text{H}_2\text{O}$ 1

[8]

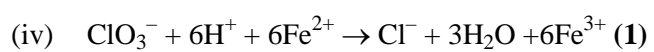
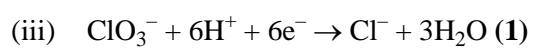
5. (a) (i) Loss (of electrons) (1)
(ii) Oxidation state of nitrogen in NO: (+) 2 (1)
Oxidation state of nitrogen in NH^+ : -3 (1)
(iii) I_2 (1) 4
- (b) (i) $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$ (1)
(ii) $\text{SO}_2 + 2\text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$ (1)
(iii) $\text{SO}_2 + 2\text{H}_2\text{O} + \text{Cl}_2 \rightarrow \text{SO}_4^{2-} + 2\text{Cl}^- + 4\text{H}^+$ (1)
or $\text{H}_2\text{SO}_4 + 2\text{HCl}$ etc

Ignore state symbols in equation
Allow multiples of all equations

3

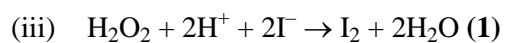
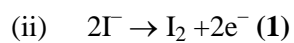
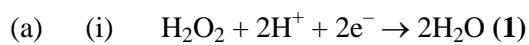
[7]

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) $\text{SO}_2 + 2\text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$ (1) (or $\text{H}_2\text{SO}_4 + 2\text{H}^+ + 2\text{e}^-$) 3
allow e i.e. no charge
penalise E^- once only
allow $-\text{e}^-$ on LHS
- (c) (i) $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$ (1)
(ii) 5 (1) (or V or +5)

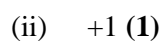
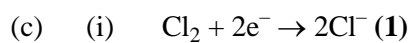


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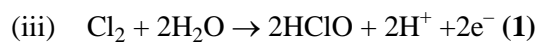
[10]



3



Allow 1, +1, Cl⁺



(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) $\text{Br}_2 + 2\text{e}^- \rightarrow 2\text{Br}^-$ 1
- (iii) $\text{SO}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{H}^+ + \text{SO}_4^{2-} + 2\text{e}^-$ 1
- (iv) $\text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{Br}^- + 4\text{H}^+ + \text{SO}_4^{2-}$ 1
- (c) $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{Cl}^- + \text{HOCl}$ 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) $\text{KCl} + \text{H}_2\text{SO}_4 \rightarrow \text{HCl} + \text{KHSO}_4$ 1
(Allow $2\text{KCl} + \text{H}_2\text{SO}_4 \rightarrow 2\text{HCl} + \text{K}_2\text{SO}_4$)
- (f) (i) Bromine 1
(ii) Sulphur dioxide 1
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
 $\text{Cl}_2 + 2\text{Br}^- \rightarrow 2\text{Cl}^- + \text{Br}_2$ 1
- (ii) cream precipitate 1
 $\text{Br}^- + \text{Ag}^+ \rightarrow \text{AgBr}$ 1
Precipitate dissolves 1

[13]

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

(c) $2\text{H}^+ + \text{H}_2\text{SO}_4 + 2\text{Br}^- \rightarrow \text{SO}_2 + \text{Br}_2 + 2\text{H}_2\text{O}$ (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)

$\text{Cl}_2 + 2\text{Br}^- \rightarrow 2\text{Cl}^- + \text{Br}_2$ (1)

allow use of NaBr, HBr etc

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

$\text{Cl}_2 + 2\text{I}^- \rightarrow 2\text{Cl}^- + \text{I}_2$ (1)

allow use of NaBr etc, penalise HI once only

I_2 brown solution / black solid (1)

do not allow any reference to purple

$\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$ (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
	<i>Any 2 marks</i>	
	(iii) $\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{SO}_2 + 2\text{H}_2\text{O}$	1
	$\text{SO}_4^{2-} + 8\text{H}^+ + 6\text{e}^- \rightarrow \text{S} + 4\text{H}_2\text{O}$	1
	$\text{SO}_4^{2-} + 10\text{H}^+ + 8\text{e}^- \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$	
	<i>Any 2 marks</i>	
	<i>(Allow equations with H₂SO₄)</i>	
(c)	$\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{Cl}^- + \text{HOCl}$	
	or $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow 2\text{H}^+ + \text{Cl}^- + \text{OCl}^-$	
	or $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + \text{HOCl}$	
	Water is not oxidised	
	The oxidation states of O (-2) and H(+1) remain unchanged	3
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

[15]

- (d) $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaOCl} + \text{H}_2\text{O}$ 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 / precipitate (1)
Equation: $\text{I}^-(\text{aq}) + \text{Ag}^+(\text{aq}) \rightarrow \text{AgI}(\text{s})$ (1) 3
or $\text{NaI}(\text{aq}) + \text{AgNO}_3(\text{aq}) \rightarrow \text{NaNO}_3(\text{aq}) + \text{AgI}(\text{s})$
no ss no marks

- (d) *Observation: steamy / white / misty fumes (1)*
NOT smoke / gas
Equation: $\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HCl}$ 2
Ignore ss

- (e) *Observation 1: black / grey solid*
lilac / purple gas
pungent / steamy / choking fumes / steam
Observation 2: yellow solid / smell bad eggs / stink bombs (2)
any two mark first one on each line
Equation: $2\text{NaI} + 2\text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O} + \text{I}_2 + \text{SO}_2$
two reduction products from Na_2SO_4 e.g. H_2S or S or $\text{SO}_2 + \text{I}_2(\text{s})$ (1) 4
balanced equation (1)

- (f) *Observation: (Starts) blue or black (1) \rightarrow colourless (1)*
Equation: $\text{I}_2 + 2\text{Na}_2\text{S}_2\text{O}_3 \rightarrow 2\text{NaI} + \text{Na}_2\text{S}_4\text{O}_6$ (1) 3
(or $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$)

[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)
 $\text{Cl}_2 + 2\text{KI} \rightarrow 2\text{KCl} + \text{I}_2$; 1
 (or ionic equation)
- (c) SO_2 ; 1
 $\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{SO}_2 + 2\text{H}_2\text{O}$; 1
 S (also H_2S); 1
 $\text{SO}_4^{2-} + 8\text{H}^+ + 6\text{e}^- \rightarrow \text{S} + 4\text{H}_2\text{O}$ (or $\text{SO}_4^{2-} + 10\text{H}^+ + 6\text{e}^- \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$); 1
- (d) $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaOCl} + \text{H}_2\text{O}$; 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)
Not atoms or molecules
- (iii) Smell of bad eggs (1)
Allow PbAc₂ goes black and K₂Cr₂O₇/H⁺ goes cloudy green
- (iv) $8\text{e}^- + 8\text{H}^+ + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$ (1)
OR $10\text{H}^+ + \text{SO}_4^{2-}$

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. HF₂ or H₂F

(ii) NaF or NaCl or F⁻ or Cl⁻ (1)

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

(iv) H⁺ + F⁻ → HF

OR H₂SO₄ + NaF → NaHSO₄ + HF

OR H₂SO₄ + 2 NaF → Na₂SO₄ + 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 not names, gases or fumes, not solutions
 brown fumes (1)
or yellow–brown or orange, not yellow
 I_2 (1)
 violet fumes or black solid (1)
or purple fumes
- (ii) SO_2 (1) S (1) H_2S (1)
 S and H_2S (1)
Penalise missing S once only
- (iii) HBr (1) HI (1) (not steam)
name or formula
penalise wrong state symbols once only
 acid–base or 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)
 $\text{Be}(\text{OH})_2$ is amphoteric (1)
 dissolves in excess NaOH (1)
 forming $[\text{Be}(\text{OH})_4]^{2-}$ 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) $2\text{HNO}_3 + \text{Na}_2\text{CO}_3 \rightarrow 2\text{NaNO}_3 + \text{CO}_2 + \text{H}_2\text{O}$ (1)

2

- (b) (i) Γ 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

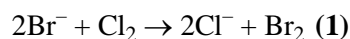
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[6]

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

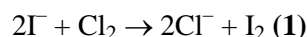


Allow molecular equations; allow equations with KBr; ignore state symbols

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



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)

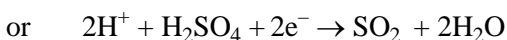
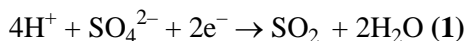
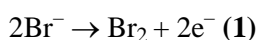
Smell of bad eggs (1)

Stated reduction products;- $\text{SO}_2, \text{S}, \text{H}_2\text{S}$ (all three must be given) (1)

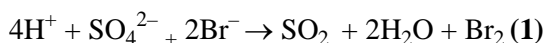
Do not extract these products from equations; wrong if extra product(s) given

Half-equations

Ignore state symbols in equations



Overall equation



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 NH_3 (aq) (1)
AgBr precipitate sparingly soluble in dilute NH_3 (aq)
OR soluble in concentrated NH_3 (aq) (1)

AgI precipitate insoluble in concentrated
NH_3 (aq) (1) | 7 |
| | Silver astatide | AgAt precipitate insoluble in concentrated NH_3 (aq) (1)
Solubility of AgX decreases down Group VII
OR as AgI insoluble predict AgAt insoluble (1) | 2 |
| 25. | (a) Oxidising power decreases, $\text{Cl}_2 > \text{Br}_2 > \text{I}_2$ (1) | | 1 |

[9]

- (b) Observation with aqueous KCl Yellow solution or no reaction (1)
Observation with aqueous KI Brown solution or black precipitate (1)
Ionic equation $2\text{I}^- + \text{Br}_2 \longrightarrow 2\text{Br}^- + \text{I}_2$ (1) 3
- (c) (i) Cl_2 (1)
(ii) $\text{H}_2\text{O} + \text{Cl}_2 \rightleftharpoons \text{HCl} + \text{HClO}$ (1)
(iii) Red colour due to presence of acid or H^+ ions (1)
White due to bleaching by HClO (1) 4
- (d) $2\text{NaOH} + \text{Cl}_2 \longrightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$ (1) 1

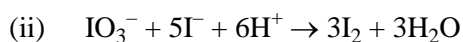
[9]

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 / $\text{Na}_2\text{S}_2\text{O}_3$ only (1) 4
- (ii) $2\text{AgNO}_3 + \text{CaI}_2 \longrightarrow 2\text{AgI} + \text{Ca}(\text{NO}_3)_2$
or $\text{Ag}^+ + \text{I}^- \longrightarrow \text{AgI}$ (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) $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightleftharpoons \text{BaSO}_4(\text{s})$
for ionic equation (1)
for state symbols (may be awarded from a molecular equation) (1) 2
- (c) (i) $\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{HCl} + \text{NaHSO}_4$ (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) $2\text{HBr} + \text{H}_2\text{SO}_4 \rightarrow \text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$
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** Cl₂(aq) colourless/green / yellow
 green / yellow (1)
 yellow / orange / brown (solution) / black (precipitate) (1)
not clear, **not** purple
 if yellow given for Cl₂ (aq), must be darker colour for mixture 2
- (ii) $2\text{KI} + \text{Cl}_2 \rightarrow 2\text{KCl} + \text{I}_2$
or $\text{KI} + \frac{1}{2}\text{Cl}_2 \rightarrow \text{KCl} + \frac{1}{2}\text{I}_2$
or $\text{I}^- + \frac{1}{2}\text{Cl}_2 \rightarrow \text{Cl}^- + \frac{1}{2}\text{I}_2$
or $2\text{I}^- + \text{Cl}_2 \rightarrow 2\text{Cl}^- + \text{I}_2$ (1)
not an equation with ClO⁻ 1
- (iii) iodide / I⁻ / KI / potassium iodide (1) 1
- (iv) $\frac{1}{2}\text{Cl}_2 + \text{e}^- \rightarrow \text{Cl}^-$
or $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$ (1)
 $\text{I}^- \rightarrow \frac{1}{2}\text{I}_2 + \text{e}^-$
or $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$ (1)
 allow 1 mark for oxidising and reducing in wrong spaces 2
- (d) (i) oxidation number of iodine in IO₃⁻ = V / +5 (1)
 oxidation number of iodine in I⁻ = -1 (1)
 oxidation number of iodine in I₂ = 0 (1)
 penalise 5+ and 1- once; penalise twice if 5 and 1 given 3



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

allow $\text{KIO}_3 \equiv \text{IO}_3^-$ and $\text{KI} \equiv \text{I}_2$ for species mark

if K included, K^+ must appear on r.h.s. for balanced mark

similarly for $\text{H}_2\text{SO}_4 / \text{HCl}$ 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

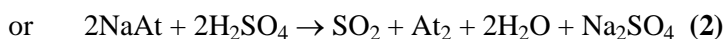
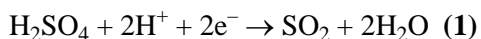
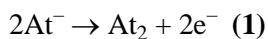
(c) $\text{HAt}(\text{g})$ (1)

Astatide a base/proton acceptor (1)



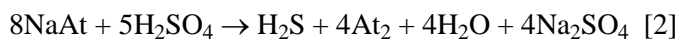
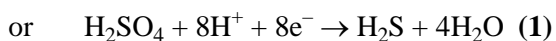
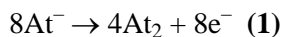
$\text{SO}_2(\text{g})$ (1)

Astatide a reducing agent (1)



$\text{H}_2\text{S}(\text{g})$ (1)

Astatide a reducing agent (1)



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 / molecules 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 atom to withdraw electrons (1)
 from a covalent bond (1)
 (ii) attraction for electron pair goes down as size of atoms or shielding goes up (1) 3

(b) *Effect on bond polarity* None (1)
Explanation equal and opposite effect from each atom cancels out (1) 2

(c) (i) SO₂ (1)
 SO₂ (1) H₂S (1)
 (ii) Br₂ (1) brown fumes (1)
 I₂ 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) $\text{HI} \rightarrow \frac{1}{2} \text{I}_2 + \text{H}^+ + \text{e}^-$ (1)
(ii) $8\text{H}^+ + \text{H}_2\text{SO}_4 + 8\text{e}^- \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$ (1)
(iii) $2\text{H}^+ + \text{H}_2\text{SO}_4 + 2\text{e}^- \rightarrow \text{SO}_2 + 2\text{H}_2\text{O}$ (1)
(iv) $10\text{HI} + 2\text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{S} + \text{SO}_2 + 5\text{I}_2 + 6\text{H}_2\text{O}$
components (1) balance (1) 5
- (c) *Equation* $2\text{OH}^- + \text{Cl}_2 \rightarrow \text{OCl}^- + \text{Cl}^- + \text{H}_2\text{O}$ (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) $\text{NaCl} + \text{Cl}_2$ no observable change (1)
 $\text{NaBr} + \text{Cl}_2$ orange/yellow solution formed (1) of bromine (1)
 $\text{NaI} + \text{Cl}_2$ red/brown solution formed or black precipitate (1)
of iodine (1)
- Equations $2\text{NaBr} + \text{Cl}_2 \rightarrow 2\text{NaCl} + \text{Br}_2$ Reagents (1); balance (1)
 $2\text{NaI} + \text{Cl}_2 \rightarrow 2\text{NaCl} + \text{I}_2$ Reagents (1); balance (1)
- (b) (i) $\text{ClO}^- + 2\text{I}^- + 2\text{H}^+ \rightarrow \text{I}_2 + \text{Cl}^- + \text{H}_2\text{O}$ Reagents (1); balance (1)
 $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$ Reagents (1); balance (1)
Starch indicator (1) End-point:- Blue (1) to colourless (1)

13

(ii) mol thio = $23.0 \times 10^{-3} \times 0.100$ (1) = 2.3×10^{-3}
 mol I₂ = mol thio/2 (1)
 = 1.15×10^{-3} (1)

mol ClO⁻ in 25 cm³ diluted solution = mol I₂ (1)
 = 1.15×10^{-3} (1)

mol ClO⁻ in 250cm³ diluted solution = $10 \times 1.15 \times 10^{-3}$ (1)
 = 1.15×10^{-2} (1)

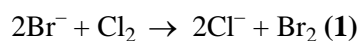
mol ClO⁻ in original 10 cm³ solution = 1.15×10^{-2} (1)

Multiply by 100 to convert 10 cm³ to 1.0 dm³ (1)
 Hence mol dm⁻³ = $100 \times 1.15 \times 10^{-2}$
 = 1.15 (1)

17

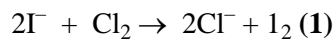
[30]

33. (a) Cl₂(aq) to Br⁻(aq); yellow-orange or yellow-red or yellow-brown solution (1)



or molecular equation

Cl₂(aq) to I⁻(aq); brown/black solution formed or black/brown/grey ppt/solid (1)



or molecular equation

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)

SO₂, S, H₂S produced (one mark each) (3)

5

Half-equations	$2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$ OR	
	$2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$ (1)	
	$\text{H}_2\text{SO}_4 + 2\text{e}^- + 2\text{H}^+ \rightarrow \text{SO}_2$	+2H₂O OR
	$\text{H}_2\text{SO}_4 + 6\text{e}^- + 6\text{H}^+ \rightarrow \text{S}$	+4H₂O OR
	$\text{H}_2\text{SO}_4 + 8\text{e}^- + 8\text{H}^+ \rightarrow \text{H}_2\text{S}$	+4H₂O (1)
Overall equation	Any correct equation based on half-equations (1)	
		3

[15]

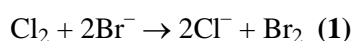
34. (a) (i) Increase from F_2 to I_2 **(1)**
- (ii) Intermolecular (van der Waals) forces increase **(1)**
as Mr/molec radius/No of electron shells increases **(1)**
- (iii) $\text{Cl}_2 = \text{gas}$, $\text{Br}_2 = \text{liquid}$, $\text{I}_2 = \text{solid}$ **(1)**
 \therefore Astatine = solid **(1)** 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)**
- Γ , in addition, gives oxidation state +O (S) **(1)**
and oxidation state -2 (H_2S) **(1)** 7
- (c) (i) $\text{Cl}_2 + 2\text{OH}^- \rightleftharpoons \text{Cl}^- + \text{OCl}^- + \text{H}_2\text{O}$ **(1)**
- (ii) Cl_2 has oxidation state 0 **(1)**
 Cl^- has oxidation state -1 **(1)**
 OCl^- has oxidation state +1 **(1)**
- (iii) Oxidising agent in forward direction Cl_2 **(1)**
Reducing agent in backward direction Cl^- **(1)** 6

[18]

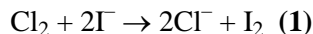
35. (a) Decreases (1)
Atomic radius increases (1)
due to more shells or due to more shielding (1) 3
- (b) Increases (1)
Molecular size or surface area increases (1)
Intermolecular van der Waals' forces increase (1) 3
- (c) Br₂ in non-polar or atoms have same electronegativity (1)
weak van der Waals' forces between Br₂ molecules (1)
I-Cl is polar or atoms have different electronegativities (1)
Dipole-dipole attractive forces between ICl molecules (1) 4

[10]

36. Br⁻ present because orange – brown fumes of bromine liberated (1)



I⁻ present because black precipitate of iodine formed (1)



AgI precipitate insoluble in concentrated ammonia (1)

AgBr precipitate soluble in concentrated ammonia (1)

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

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

$$\text{Hence mass AgBr} = 0.902 - 0.564 = 0.338\text{g} \quad (1)$$

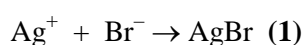
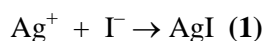
$$\text{Moles AgBr} = \text{mass}/M_r = 0.338/188 \quad (1) \quad = 1.8 \times 10^{-3}$$

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

$$\text{Percentage Br}^- \text{ in sample} = 0.144 \times 100/0.545 = 26.4\% \quad (26 - 27) \quad (1)$$

$$\text{Percentage I}^- \text{ in sample} = 0.305 \times 100/0.545 = 55.96\% \quad (56 \pm 0.5) \quad (1)$$

Equation marks



[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) $\text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons 2\text{H}^+ + \text{ClO}^- + \text{Cl}^-$ (1)
- (ii) OH^- removes H^+ (1) displacing equilibrium to the right (1)
 $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ (1)
 or $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaClO} + \text{NaCl} + \text{H}_2\text{O}$ 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 trend) 1
 Sulphate solubility decreases (need trend) 1
- (If both Mg/Ba salts correctly compared - but no trend- allow 1 max)
- Add acid name/correct formula HCl 1

- (ii) (accept $\text{HNO}_3/\text{CH}_3\text{COOH}$) [NOT hydrogen chloride] 1
 [If acid added is $\text{H}_2\text{SO}_4 = \text{CE} - \text{allow only M2}$]
- Add Ba^{2+} salt name/correct formula BaCl_2 1
 (accept $\text{Ba}(\text{NO}_3)_2 / \text{Ba}(\text{CH}_3\text{COO})_2$)
 [If reagent added is $\text{BaSO}_4/\text{Ba}/\text{Ba}(\text{OH})_2 = \text{CE} - \text{allow only M1}$]
- 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
- $\text{MgSO}_4 + \text{BaCl}_2 \rightarrow \text{BaSO}_4 + \text{MgCl}_2$ 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
 $\text{Ba} + 2\text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2 + \text{H}_2$ 1

[11]

41. Tendency **or** strength **or** ability **or** power of an atom/element/nucleus to 1
 attract/withdraw electrons / e^- density / bonding pair / shared pair
- In a covalent 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 1
 electrons further from nucleus
 [NOT ‘increase in number of electrons’]
- Decreased attraction for (bonding) electrons 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 ($>100^\circ$) (NOT 'hot') 1
 $\text{Mg} + \text{H}_2\text{O} \rightarrow \text{MgO} + \text{H}_2$ 1
(Ignore state symbols – even if they are wrong)
- (b) White precipitate/solid/suspension (Not 'cloudy / milky') 1
 $\text{BeCl}_2 + 2\text{NaOH} \rightarrow \text{Be}(\text{OH})_2 + 2\text{NaCl}$
 Or $\text{Be}^{2+} + 2\text{OH}^- \rightarrow \text{Be}(\text{OH})_2$ 1
(Accept $\text{BeCl}_2 + 2\text{OH}^- \rightarrow \text{Be}(\text{OH})_2 + 2\text{Cl}^-$)
- Ppt (re)dissolves or solution goes clear 1
(Allow 'ppt disappears')
(NOT 'solution forms')
- $\text{Be}(\text{OH})_2 + 2\text{OH}^- \rightarrow \text{Be}(\text{OH})_4^{2-}$
[NOT $\text{Be}(\text{OH})_6^{4-}$]
- Or $\text{Be}(\text{OH})_2 + 2\text{NaOH} \rightarrow \text{Na}_2\text{Be}(\text{OH})_4$ 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



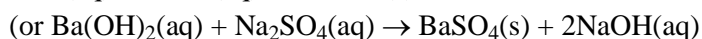
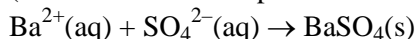
Species all correct (1)

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)



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 $\text{Be}(\text{OH})_2$ is insoluble (1) (or white ppt is $\text{Be}(\text{OH})_2$)
 ppt is soluble in excess reagent (1)
 Because $\text{Be}(\text{OH})_2$ is amphoteric (or beryllium forms complex ion
 $(\text{Be}(\text{OH})_4)^{2-}$) (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 $\text{Mg}(\text{OH})_2$ is sparingly soluble (or insoluble) (1) (or white ppt is
 $\text{Mg}(\text{OH})_2$)

With BaCl_2 no ppt formed (1) (or no reaction) (or remains in solution)

Because $\text{Ba}(\text{OH})_2$ is soluble (1) (or all species are soluble)

Solubility of hydroxides increases down Group (1)

**Note can take marks for $\text{Be}(\text{OH})_2(\text{s})$, $\text{Mg}(\text{OH})_2(\text{s})$, $\text{Ba}(\text{OH})_2(\text{aq})$
 from equations**

Wrong formula for $\text{M}(\text{OH})_2$ loses mark

max 8

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

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

Allow 40, 32

$$= 1 : 1 : 6 :$$

 therefore formula: CaSO_6H_4 (1)
if Oxygen omitted can score 2nd mark only

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

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) $\text{Ca} + 2\text{H}_2\text{O} \longrightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$ (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) $\text{ClO}^-: (+)1 \quad \text{Cl}^-: -1$ [condone $\text{ClO}^-: 1+$ and $\text{Cl}^-: 1-$] (1) 1
- (v) $\Gamma^-: -1 \quad \text{I}_2: 0$ [condone 1- for Γ^-] (1) 1
- (vi) $\text{ClO}^- + 2\text{H}^+ + 2\text{I}^- \longrightarrow \text{Cl}^- + \text{I}_2 + \text{H}_2\text{O}$ (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.

delocalised electrons mentioned in a sentence explaining metallic bonding (1)

energy required to break bonds (1)

Note: last mark not 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 P₄)

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, P₄ 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)
 $\text{Mg} + \text{H}_2\text{O} \rightarrow \text{MgO} + \text{H}_2$ (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)
 $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$ (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.*
- $\text{Be}(\text{OH})_2$ 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)
 $\text{Be}(\text{OH})_2 + 2\text{H}^+ \rightarrow \text{Be}^{2+} + 2\text{H}_2\text{O}$ (1) (or $\text{Be}(\text{OH})_2 + 2\text{HCl} \rightarrow \text{BeCl}_2 + 2\text{H}_2\text{O}$ etc)
 $\text{Be}(\text{OH})_2 + 2\text{H}^+ \rightarrow \text{Be}(\text{OH})_4^{2-}$ (1) (or $\text{Be}(\text{OH})_2 + 2\text{NaOH} \rightarrow 2\text{Na}^+ + \text{Be}(\text{OH})_4^{2-}$ etc)
 magnesium hydroxide basic (1) (or GpII hydroxides basic)
 soluble in acid (1) (or reacts with acid)
 $\text{Mg}(\text{OH})_2 + 2\text{H}^+ \rightarrow \text{Mg}^{2+} + 2\text{H}_2\text{O}$ (1) (or $\text{Mg}(\text{OH})_2 + 2\text{HCl} \rightarrow \text{MgCl}_2 + 2\text{H}_2\text{O}$)
 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]