

- M1.** (a) (i) An atom, ion or molecule which can donate a lone electron pair 1
- (ii) A central metal ion/species surrounded by co-ordinately bonded ligands or ion in which co-ordination number exceeds oxidation state 1
- (iii) The number of co-ordinate bonds formed to a central metal ion or number of electron pairs donated or donor atoms 1
- (b) (i) *Allow the reverse of each substitution*
- $$[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 6\text{NH}_3 \rightarrow [\text{Co}(\text{NH}_3)_6]^{2+} + 6\text{H}_2\text{O}$$
- Complex ions 1
- Balanced 1
- Allow partial substitution*
- (ii) $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightarrow \text{CoCl}_4^{2-} + 6\text{H}_2\text{O}$
- Complex ions 1
- Balanced 1
- or H₂O or NH₃ or C₂O₄²⁻ by Cl⁻* 1
- eg. (iii) $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 3\text{C}_2\text{O}_4^{2-} \rightarrow [\text{Co}(\text{C}_2\text{O}_4)_3]^{4-} + 6\text{H}_2\text{O}$
- Complex ions 1
- Balanced 1
- Allow all substitution except*
- (i) NH₃ by H₂O*
- (ii) more than 2Cl⁻ substituted for NH₃ or H₂O*



Complex ions

1

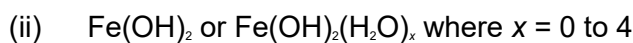
Balanced

or H_2O or NH_3 by $\text{C}_2\text{O}_4^{2-}$ and NH_3 or Cl^- by EDTA^{4-}

1



1



1



1

By oxygen in the air

1

[15]

M2. (a) (i) Deductions:

Ionic (1)

Ions not free to move in the solid state (1)

Ions free to move when molten or in aqueous solution (1)

Identity of **P**: Na_2O or sodium oxide (1)

N.B. If a formula given this must be correct



5

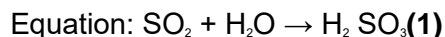
(ii) Deductions:

Covalent

Intermolecular forces are weak or van der Waals forces,
or dipole-dipole

*N.B. Any answer including a reference to hydrogen bonding
is incorrect*

Identity of **Q**: SO_2 or sulphur dioxide (1)

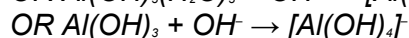
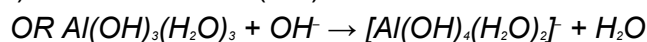
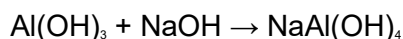


NB Allow max one for SO_3

4

(b) (i) Amphoteric (1)

(ii) Equation with NaOH



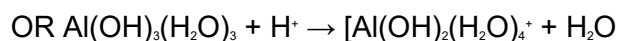
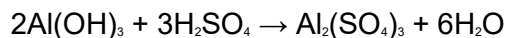
R identified as $\text{Al}(\text{OH})_3$ or $\text{Al}(\text{OH})_3(\text{H}_2\text{O})_3$ (1)

A balanced equation (1)

N.B. Allow equation with six co-ordinate Aluminium and up to six OH ligands

N.B. Allow equation mark if $\text{M}(\text{OH})_3$ given in a balanced equation

Equation with H_2SO_4



NB Allow equations with six co-ordinate Aluminium and up to six H_2O ligands NB Allow equation mark if $\text{M}(\text{OH})_3$ given in a balanced equation

Correct Al species as product (1)

A balanced equation (1)

(iii) Large lattice energy
or strong covalent bonds

or ΔH_{soln} is very positive

or ΔG is positive

or sum of hydration energies less than covalent bond energies (1)

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