

- 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 H<sub>2</sub>O or NH<sub>3</sub> or C<sub>2</sub>O<sub>4</sub><sup>2-</sup> by Cl<sup>-</sup>* 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) NH<sub>3</sub> by H<sub>2</sub>O*
- (ii) more than 2Cl<sup>-</sup> substituted for NH<sub>3</sub> or H<sub>2</sub>O*



Complex ions

1

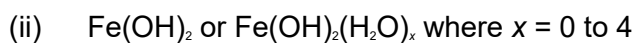
Balanced

or  $\text{H}_2\text{O}$  or  $\text{NH}_3$  by  $\text{C}_2\text{O}_4^{2-}$  and  $\text{NH}_3$  or  $\text{Cl}^-$  by  $\text{EDTA}^{4-}$

1



1



1



1

By oxygen in the air

1

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**M2.** (a) (i) Deductions:

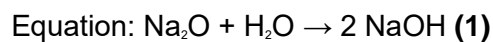
Ionic (1)

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

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

Identity of **P**:  $\text{Na}_2\text{O}$  or sodium oxide (1)

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



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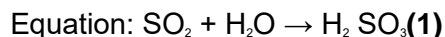
(ii) Deductions:

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**:  $\text{SO}_2$  or sulphur dioxide (1)

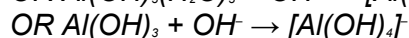
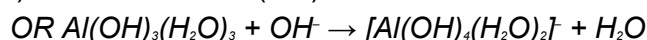
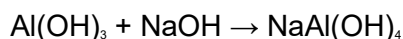


*NB Allow max one for  $\text{SO}_3$*

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(b) (i) Amphoteric (1)

(ii) Equation with NaOH



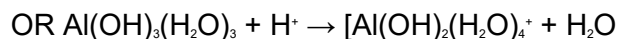
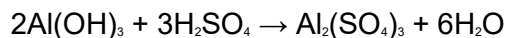
**R** identified as  $\text{Al}(\text{OH})_3$  or  $\text{Al}(\text{OH})_3(\text{H}_2\text{O})_3$  (1)

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  $\text{H}_2\text{SO}_4$



*NB Allow equations with six co-ordinate Aluminium and up to six  $\text{H}_2\text{O}$  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  $\Delta H_{\text{soln}}$  is very positive

or  $\Delta G$  is positive

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

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