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# Bis[hexaamminecobalt(III)] pentachloride nitrate

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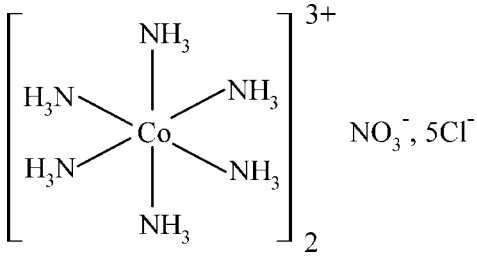
Key indicators: single-crystal X-ray study; $T$ = 296 K; mean $\sigma$(O–N) = 0.005 Å; $R$ factor = 0.050; $wR$ factor = 0.140; data-to-parameter ratio = 23.6.

The title compound, $[Co(NH_3)_6]_2Cl_5(NO_3)$, was obtained under hydrothermal conditions. The asymmetric unit contains three $Co^{3+}$ ions, one lying on an inversion center and the other two located at 2/$m$ positions. All $Co^{3+}$ ions are six-coordinated by $NH_3$ molecules, forming $[Co(NH_3)_6]^{3+}$ octahedra, with Co—N distances in the range 1.945 (4)–1.967 (3) Å. The nitrate N atom and one of the O atoms lie at a mirror plane. Among the $Cl^-$ anions, one lies in a general position, one on a twofold axis and two on a mirror plane. N—H···O and N—H···Cl hydrogen bonds link the cations and anions into a three-dimensional network.

## Related literature

For metal phosphates and germanates prepared using metal complexes as templates, see: Wang *et al.* (2003*a*,*b*); Pan *et al.* (2005, 2008). For our continued research interest focused on the synthesis of microporous open-framework metal-organic hybride materials by introducing transition metal complexes as templates, see: Pan *et al.* (2010*a*,*b*, 2011); Tong & Pan (2011); Liang *et al.* (2011). For a structure containing a $[Co(NH_3)_6]^{3+}$ cation, see: Han *et al.* (2012).




## Experimental

### Crystal data

$[Co(NH_3)_6]_2Cl_5(NO_3)$
$M_r$ = 561.53
Monoclinic, $C2/m$
$a$ = 21.118 (4) Å
$b$ = 14.985 (3) Å
$c$ = 6.8491 (11) Å
$\beta$ = 92.147 (3)°
$V$ = 2165.8 (6) Å$^3$
$Z$ = 4
Mo $K\alpha$ radiation
$\mu$ = 2.18 mm$^{-1}$
$T$ = 296 K
0.20 × 0.12 × 0.10 mm

### Data collection

Bruker APEXII CCD area-detector diffractometer
Absorption correction: multi-scan (*SADABS*; Bruker, 2005)
$T_{min}$ = 0.738, $T_{max}$ = 0.770
7927 measured reflections
2813 independent reflections
1870 reflections with $I > 2\sigma(I)$
$R_{int}$ = 0.046

### Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.050
$wR(F^2)$ = 0.140
$S$ = 1.02
2813 reflections
119 parameters
H-atom parameters constrained
$\Delta\rho_{max}$ = 0.65 e Å$^{-3}$
$\Delta\rho_{min}$ = −0.71 e Å$^{-3}$

**Table 1**
Hydrogen-bond geometry (Å, °).

| $D$—H···$A$ | $D$—H | H···$A$ | $D$···$A$ | $D$—H···$A$ |
|---|---|---|---|---|
| N1—H1$A$···Cl1 | 0.89 | 2.89 | 3.427 (4) | 120 |
| N1—H1$A$···Cl3$^{i}$ | 0.89 | 2.90 | 3.484 (4) | 125 |
| N1—H1$B$···Cl1$^{ii}$ | 0.89 | 2.59 | 3.410 (4) | 154 |
| N1—H1$C$···Cl3$^{iii}$ | 0.89 | 2.63 | 3.431 (4) | 150 |
| N3—H3$A$···O2$^{iv}$ | 0.89 | 2.53 | 3.155 (6) | 128 |
| N4—H4$A$···Cl3$^{v}$ | 0.89 | 2.79 | 3.287 (4) | 117 |
| N4—H4$B$···Cl4 | 0.89 | 2.62 | 3.448 (5) | 155 |
| N4—H4$C$···Cl2$^{v}$ | 0.89 | 2.73 | 3.321 (4) | 125 |
| N5—H5$A$···Cl1$^{vi}$ | 0.89 | 2.77 | 3.375 (4) | 127 |
| N5—H5$A$···Cl4$^{vii}$ | 0.89 | 2.91 | 3.456 (4) | 122 |
| N5—H5$B$···O2$^{vii}$ | 0.89 | 2.17 | 3.048 (5) | 168 |
| N5—H5$C$···Cl3$^{vi}$ | 0.89 | 2.56 | 3.337 (4) | 146 |
| N6—H6$A$···Cl4$^{vii}$ | 0.89 | 2.76 | 3.339 (4) | 124 |
| N6—H6$C$···Cl3$^{viii}$ | 0.89 | 2.93 | 3.445 (4) | 118 |
| N7—H7$A$···Cl4$^{iv}$ | 0.89 | 2.78 | 3.368 (4) | 125 |
| N7—H7$B$···Cl3$^{viii}$ | 0.89 | 2.87 | 3.394 (4) | 119 |

Symmetry codes: (i) $x, -y+1, z$; (ii) $-x, -y+1, -z+1$; (iii) $-x, -y+1, -z$; (iv) $-x+1, -y+1, -z+1$; (v) $x+\frac{1}{2}, y+\frac{1}{2}, z$; (vi) $-x+\frac{1}{2}, -y+\frac{1}{2}, -z+1$; (vii) $x-\frac{1}{2}, y-\frac{1}{2}, z$; (viii) $x, y, z+1$.

Data collection: *APEX2* (Bruker, 2005); cell refinement: *SAINT* (Bruker, 2005); data reduction: *SAINT*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *SHELXTL* (Sheldrick, 2008); software used to prepare material for publication: *SHELXTL*.

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Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: YK2056).

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# supplementary materials

*Acta Cryst.* (2012). E**68**, i45–i46 [doi:10.1107/S1600536812021332]

## Bis[hexaamminecobalt(III)] pentachloride nitrate

**Qihui Wu, Chunyu Du, Yang Lv, Guoliang Chen and Qinhe Pan**

### Comment

Rencently, more attention has been paid to transition metal complexes, because they can to be employed as templates in the synthesis of various open-framework materials, including metal phosphates (Wang *et al.*, 2003*a,b*) and germanates (Pan *et al.*, 2005,2008). Our continued interest has been focused on the synthesis of microporous open-framework metal-organic hybride materials by introducing transition metal complexes as templates (Pan *et al.*, 2010*a,b*, 2011; Tong & Pan, 2011; Liang *et al.*, 2011). Unexpectedly, the title compound, $[Co(NH_3)_6]_2(NO_3)Cl_5$, was obtained.

The title compound is composed of $[Co(NH_3)_6]^{3+}$ cations and the counterions $Cl^-$ and $NO_3^-$, as shown in Fig. 1. The asymmetric part of this crystal structure contains three $Co^{3+}$ ions; one is located on an inversion center, and the other two are positioned on the twofold rotation axis with center of symmetry (2/m). All Co(III) ions are six coordinated by $NH_3$ molecules to form $[Co(NH_3)_6]^{3+}$ cations, having a slightly distorted octahedral geometry, as in the structure of $[Co(NH_3)_6]_3[Zn_8(HPO_4)_8(PO_4)_2](PO_4)$ (Han *et al.*, 2012). The Co—N bond distances are in the range from 1.945 (4) to 1.967 (3) Å. For the counterions, the N8 atom of $NO_3^-$ anion is located on mirror plane and displays a trigonal geometry by bonded to three O atoms with the N—O distances of 1.234 (6)–1.253 (4) Å. The $Cl^-$ anions are located in different positions: inversion center for Cl2, mirror plane for Cl1 and Cl4, and general position for Cl3. The $[Co(NH_3)_6]^{3+}$ cations interact with the counterions $Cl^-$ and $NO_3^-$ *via* hydrogen bonds; the distances of N—H···O hydrogen bonds are in the range 3.048 (5)–3.155 (6) Å, and the distances of N—H···Cl hydrogen bonds lie in the range from 3.287 (4) to 3.484 (4) Å (Table 1), to form an extensive three-dimensional hydrogen-bonding network.

### Experimental

In a typical synthesis, a mixture of $Cd(NO_3)_2.4H_2O$ (0.231 g), pyromellitic acid (0.0254 g), $[Co(NH_3)_6]Cl_3$ (0.03 g), NaOH (0.016 g) and $H_2O$ (10 ml) were added in a 20 ml Teflon-lined reactor under autogenous pressure at 100°C for 3 days. Yellow rod-like crystals were obtained.

### Refinement

All H atoms were positioned geometrically (N—H = 0.89 Å) and allowed to ride on their parent atoms, with $U_{iso}$(H) = 1.2$U_{eq}$(parent atom).

### Computing details

Data collection: *APEX2* (Bruker, 2005); cell refinement: *SAINT* (Bruker, 2005); data reduction: *SAINT* (Bruker, 2005); program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *SHELXTL* (Sheldrick, 2008); software used to prepare material for publication: *SHELXTL* (Sheldrick, 2008).

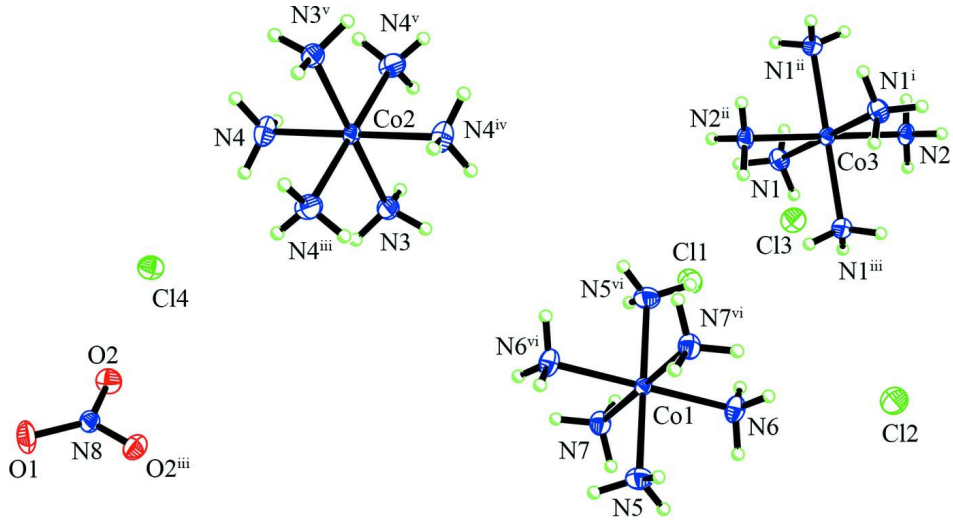


**Figure 1**

A view of the asymmetric unit of title compound showing the atom labelling scheme. Ellipsoids are drawn at the 30% probability level. [Symmetry codes: (i) -*x*, 1 - *y*, -*z*; (ii) -*x*, *y*, -*z*; (iii) *x*, 1 - *y*, *z*; (iv) 1 - *x*, 1 - *y*, -*z*; (v) 1 - *x*, *y*, -*z*; (vi) 1/2 - *x*, 1/2 - *y*, 1 - *z*]. (iv) *x*, -*y* + 1, *z*; (v) -*x*, -*y* + 1, -*z*; (vi) -*x*, *y*, -*z*.

### Bis[hexaamminecobalt(III)] pentachloride nitrate

*Crystal data*

$[Co(NH_3)_6]_2Cl_5(NO_3)$
$M_r = 561.53$
Monoclinic, *C*2/*m*
Hall symbol: -C 2y
$a = 21.118$ (4) Å
$b = 14.985$ (3) Å
$c = 6.8491$ (11) Å
$\beta = 92.147$ (3)°
$V = 2165.8$ (6) Å$^3$
$Z = 4$
$F(000) = 1160$
$D_x = 1.722$ Mg m$^{-3}$
Mo $K\alpha$ radiation, $\lambda = 0.71073$ Å
Cell parameters from 7927 reflections
$\theta = 1.7$–28.4°
$\mu = 2.18$ mm$^{-1}$
$T = 296$ K
Rod, yellow
0.2 × 0.12 × 0.10 mm

*Data collection*

Bruker APEXII CCD area-detector diffractometer
Radiation source: fine-focus sealed tube
Graphite monochromator
Detector resolution: 83.66 pixels mm$^{-1}$
$\varphi$ and $\omega$ scans
Absorption correction: multi-scan (*SADABS*; Bruker, 2005)
$T_{min} = 0.738$, $T_{max} = 0.770$
7927 measured reflections
2813 independent reflections
1870 reflections with $I > 2\sigma(I)$
$R_{int} = 0.046$
$\theta_{max} = 28.4°$, $\theta_{min} = 1.7°$
$h = -27 \rightarrow 28$
$k = -19 \rightarrow 20$
$l = -6 \rightarrow 9$

*Refinement*

Refinement on $F^2$
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)] = 0.050$
$wR(F^2) = 0.140$
$S = 1.02$
2813 reflections
119 parameters
0 restraints
Primary atom site location: structure-invariant direct methods
Secondary atom site location: difference Fourier map

Hydrogen site location: inferred from neighbouring sites
H-atom parameters constrained

$w = 1/[\sigma^2(F_o^2) + (0.0641P)^2 + 4.8344P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max} = 0.65$ e Å$^{-3}$
$\Delta\rho_{min} = -0.71$ e Å$^{-3}$

*Special details*

**Geometry**. All s.u.'s (except the s.u. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell s.u.'s are taken into account individually in the estimation of s.u.'s in distances, angles and torsion angles; correlations between s.u.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell s.u.'s is used for estimating s.u.'s involving l.s. planes.

**Refinement**. Refinement of $F^2$ against ALL reflections. The weighted *R*-factor *wR* and goodness of fit *S* are based on $F^2$, conventional *R*-factors *R* are based on *F*, with *F* set to zero for negative $F^2$. The threshold expression of $F^2 > \sigma(F^2)$ is used only for calculating *R*-factors(gt) *etc*. and is not relevant to the choice of reflections for refinement. *R*-factors based on $F^2$ are statistically about twice as large as those based on *F*, and *R*- factors based on ALL data will be even larger.

*Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å$^2$)*

| | *x* | *y* | *z* | $U_{iso}$*/$U_{eq}$ |
|---|---|---|---|---|
| Co1 | 0.2500 | 0.2500 | 0.5000 | 0.0193 (2) |
| N7 | 0.25395 (17) | 0.3197 (3) | 0.7422 (5) | 0.0329 (9) |
| H7A | 0.2923 | 0.3440 | 0.7585 | 0.040* |
| H7B | 0.2465 | 0.2842 | 0.8429 | 0.040* |
| H7C | 0.2249 | 0.3627 | 0.7353 | 0.040* |
| N6 | 0.16170 (16) | 0.2158 (3) | 0.5415 (5) | 0.0342 (9) |
| H6A | 0.1477 | 0.1812 | 0.4434 | 0.041* |
| H6B | 0.1378 | 0.2646 | 0.5463 | 0.041* |
| H6C | 0.1596 | 0.1861 | 0.6535 | 0.041* |
| N5 | 0.27844 (19) | 0.1439 (3) | 0.6414 (6) | 0.0401 (10) |
| H5A | 0.2811 | 0.0984 | 0.5585 | 0.048* |
| H5B | 0.2509 | 0.1306 | 0.7323 | 0.048* |
| H5C | 0.3164 | 0.1541 | 0.6982 | 0.048* |
| Co2 | 0.5000 | 0.5000 | 0.0000 | 0.0212 (3) |
| Cl4 | 0.66930 (8) | 0.5000 | 0.4229 (2) | 0.0350 (4) |
| N4 | 0.55640 (18) | 0.5926 (3) | 0.1076 (6) | 0.0411 (10) |
| H4A | 0.5852 | 0.6062 | 0.0208 | 0.049* |
| H4B | 0.5758 | 0.5727 | 0.2168 | 0.049* |
| H4C | 0.5339 | 0.6410 | 0.1341 | 0.049* |
| N3 | 0.4522 (2) | 0.5000 | 0.2394 (7) | 0.0329 (12) |
| H3A | 0.4278 | 0.4517 | 0.2435 | 0.040* |
| H3B | 0.4787 | 0.5000 | 0.3435 | 0.040* |
| Co3 | 0.0000 | 0.5000 | 0.0000 | 0.0208 (3) |
| N2 | −0.0927 (2) | 0.5000 | −0.0085 (7) | 0.0289 (11) |
| H2A | −0.1072 | 0.4517 | −0.0712 | 0.035* |
| H2B | −0.1075 | 0.5000 | 0.1114 | 0.035* |
| N1 | 0.00050 (17) | 0.5934 (3) | 0.2019 (5) | 0.0330 (9) |
| H1A | 0.0403 | 0.6075 | 0.2360 | 0.040* |
| H1B | −0.0191 | 0.5734 | 0.3061 | 0.040* |
| H1C | −0.0195 | 0.6415 | 0.1551 | 0.040* |
| Cl3 | 0.12244 (5) | 0.28432 (8) | 0.00154 (16) | 0.0351 (3) |
| Cl2 | 0.0000 | 0.19040 (14) | 0.5000 | 0.0485 (5) |

| | | | | |
|---|---|---|---|---|
| Cl1 | 0.11173 (8) | 0.5000 | 0.5167 (2) | 0.0459 (5) |
| O2 | 0.68054 (15) | 0.5722 (2) | 0.9173 (5) | 0.0392 (8) |
| N8 | 0.7099 (2) | 0.5000 | 0.9396 (7) | 0.0291 (11) |
| O1 | 0.7671 (2) | 0.5000 | 0.9832 (8) | 0.0507 (14) |

*Atomic displacement parameters (Å²)*

| | $U^{11}$ | $U^{22}$ | $U^{33}$ | $U^{12}$ | $U^{13}$ | $U^{23}$ |
|---|---|---|---|---|---|---|
| Co1 | 0.0190 (4) | 0.0185 (4) | 0.0206 (4) | 0.0001 (3) | 0.0021 (3) | 0.0002 (3) |
| N7 | 0.032 (2) | 0.039 (2) | 0.028 (2) | −0.0044 (17) | 0.0031 (15) | −0.0072 (15) |
| N6 | 0.0265 (19) | 0.036 (2) | 0.041 (2) | −0.0052 (17) | 0.0084 (16) | −0.0079 (18) |
| N5 | 0.046 (2) | 0.032 (2) | 0.042 (2) | 0.0034 (19) | −0.0037 (18) | 0.0093 (17) |
| Co2 | 0.0179 (5) | 0.0211 (6) | 0.0247 (6) | 0.000 | 0.0025 (4) | 0.000 |
| Cl4 | 0.0419 (9) | 0.0284 (8) | 0.0347 (9) | 0.000 | −0.0006 (7) | 0.000 |
| N4 | 0.033 (2) | 0.044 (3) | 0.047 (2) | −0.0102 (19) | 0.0093 (18) | −0.0124 (19) |
| N3 | 0.027 (3) | 0.043 (3) | 0.028 (3) | 0.000 | 0.005 (2) | 0.000 |
| Co3 | 0.0165 (5) | 0.0220 (6) | 0.0239 (6) | 0.000 | 0.0019 (4) | 0.000 |
| N2 | 0.017 (2) | 0.029 (3) | 0.040 (3) | 0.000 | −0.001 (2) | 0.000 |
| N1 | 0.030 (2) | 0.035 (2) | 0.034 (2) | 0.0027 (17) | −0.0011 (16) | −0.0044 (16) |
| Cl3 | 0.0334 (6) | 0.0315 (6) | 0.0405 (7) | 0.0048 (5) | 0.0037 (5) | 0.0012 (5) |
| Cl2 | 0.0462 (10) | 0.0521 (12) | 0.0478 (11) | 0.000 | 0.0079 (8) | 0.000 |
| Cl1 | 0.0361 (9) | 0.0683 (13) | 0.0337 (9) | 0.000 | 0.0056 (7) | 0.000 |
| O2 | 0.0395 (19) | 0.036 (2) | 0.043 (2) | 0.0092 (15) | 0.0046 (15) | −0.0019 (14) |
| N8 | 0.024 (3) | 0.037 (3) | 0.027 (3) | 0.000 | 0.004 (2) | 0.000 |
| O1 | 0.022 (2) | 0.053 (4) | 0.077 (4) | 0.000 | −0.005 (2) | 0.000 |

*Geometric parameters (Å, º)*

| | | | |
|---|---|---|---|
| Co1—N5$^{i}$ | 1.945 (4) | Co2—N3$^{ii}$ | 1.958 (5) |
| Co1—N5 | 1.945 (4) | N4—H4A | 0.8900 |
| Co1—N7 | 1.960 (3) | N4—H4B | 0.8900 |
| Co1—N7$^{i}$ | 1.960 (3) | N4—H4C | 0.8900 |
| Co1—N6 | 1.965 (3) | N3—H3A | 0.8900 |
| Co1—N6$^{i}$ | 1.965 (3) | N3—H3B | 0.8900 |
| N7—H7A | 0.8900 | Co3—N2 | 1.956 (5) |
| N7—H7B | 0.8900 | Co3—N2$^{v}$ | 1.956 (5) |
| N7—H7C | 0.8900 | Co3—N1 | 1.967 (3) |
| N6—H6A | 0.8900 | Co3—N1$^{vi}$ | 1.967 (3) |
| N6—H6B | 0.8900 | Co3—N1$^{v}$ | 1.967 (3) |
| N6—H6C | 0.8900 | Co3—N1$^{iv}$ | 1.967 (3) |
| N5—H5A | 0.8900 | N2—H2A | 0.8900 |
| N5—H5B | 0.8900 | N2—H2B | 0.8900 |
| N5—H5C | 0.8900 | N1—H1A | 0.8900 |
| Co2—N4 | 1.955 (4) | N1—H1B | 0.8900 |
| Co2—N4$^{ii}$ | 1.955 (4) | N1—H1C | 0.8900 |
| Co2—N4$^{iii}$ | 1.955 (4) | O2—N8 | 1.253 (4) |
| Co2—N4$^{iv}$ | 1.955 (4) | N8—O1 | 1.234 (6) |
| Co2—N3 | 1.958 (5) | N8—O2$^{iv}$ | 1.253 (4) |
| | | | |
| N5$^{i}$—Co1—N5 | 180.000 (1) | N4$^{iv}$—Co2—N3 | 90.59 (16) |

| | | | |
|---|---|---|---|
| N5$^{i}$—Co1—N7 | 89.33 (16) | N4—Co2—N3$^{ii}$ | 89.41 (16) |
| N5—Co1—N7 | 90.67 (16) | N4$^{ii}$—Co2—N3$^{ii}$ | 90.59 (16) |
| N5$^{i}$—Co1—N7$^{i}$ | 90.67 (16) | N4$^{iii}$—Co2—N3$^{ii}$ | 90.59 (16) |
| N5—Co1—N7$^{i}$ | 89.33 (16) | N4$^{iv}$—Co2—N3$^{ii}$ | 89.41 (16) |
| N7—Co1—N7$^{i}$ | 180.0 | N3—Co2—N3$^{ii}$ | 180.000 (1) |
| N5$^{i}$—Co1—N6 | 90.47 (17) | Co2—N4—H4A | 109.5 |
| N5—Co1—N6 | 89.53 (17) | Co2—N4—H4B | 109.5 |
| N7—Co1—N6 | 91.56 (15) | H4A—N4—H4B | 109.5 |
| N7$^{i}$—Co1—N6 | 88.44 (15) | Co2—N4—H4C | 109.5 |
| N5$^{i}$—Co1—N6$^{i}$ | 89.53 (17) | H4A—N4—H4C | 109.5 |
| N5—Co1—N6$^{i}$ | 90.47 (17) | H4B—N4—H4C | 109.5 |
| N7—Co1—N6$^{i}$ | 88.44 (15) | Co2—N3—H3A | 110.1 |
| N7$^{i}$—Co1—N6$^{i}$ | 91.56 (15) | Co2—N3—H3B | 110.0 |
| N6—Co1—N6$^{i}$ | 180.00 (6) | H3A—N3—H3B | 108.9 |
| Co1—N7—H7A | 109.5 | N2—Co3—N2$^{v}$ | 180.0 |
| Co1—N7—H7B | 109.5 | N2—Co3—N1 | 90.00 (15) |
| H7A—N7—H7B | 109.5 | N2$^{v}$—Co3—N1 | 90.00 (15) |
| Co1—N7—H7C | 109.5 | N2—Co3—N1$^{vi}$ | 90.00 (15) |
| H7A—N7—H7C | 109.5 | N2$^{v}$—Co3—N1$^{vi}$ | 90.00 (15) |
| H7B—N7—H7C | 109.5 | N1—Co3—N1$^{vi}$ | 89.3 (2) |
| Co1—N6—H6A | 109.5 | N2—Co3—N1$^{v}$ | 90.00 (15) |
| Co1—N6—H6B | 109.5 | N2$^{v}$—Co3—N1$^{v}$ | 90.00 (15) |
| H6A—N6—H6B | 109.5 | N1—Co3—N1$^{v}$ | 180.0 (2) |
| Co1—N6—H6C | 109.5 | N1$^{vi}$—Co3—N1$^{v}$ | 90.7 (2) |
| H6A—N6—H6C | 109.5 | N2—Co3—N1$^{iv}$ | 90.00 (15) |
| H6B—N6—H6C | 109.5 | N2$^{v}$—Co3—N1$^{iv}$ | 90.00 (15) |
| Co1—N5—H5A | 109.5 | N1—Co3—N1$^{iv}$ | 90.7 (2) |
| Co1—N5—H5B | 109.5 | N1$^{vi}$—Co3—N1$^{iv}$ | 180.00 (16) |
| H5A—N5—H5B | 109.5 | N1$^{v}$—Co3—N1$^{iv}$ | 89.3 (2) |
| Co1—N5—H5C | 109.5 | Co3—N2—H2A | 109.9 |
| H5A—N5—H5C | 109.5 | Co3—N2—H2B | 111.0 |
| H5B—N5—H5C | 109.5 | H2A—N2—H2B | 108.6 |
| N4—Co2—N4$^{ii}$ | 180.0 | Co3—N1—H1A | 109.5 |
| N4—Co2—N4$^{iii}$ | 89.6 (3) | Co3—N1—H1B | 109.5 |
| N4$^{ii}$—Co2—N4$^{iii}$ | 90.4 (3) | H1A—N1—H1B | 109.5 |
| N4—Co2—N4$^{iv}$ | 90.4 (3) | Co3—N1—H1C | 109.5 |
| N4$^{ii}$—Co2—N4$^{iv}$ | 89.6 (3) | H1A—N1—H1C | 109.5 |
| N4$^{iii}$—Co2—N4$^{iv}$ | 180.00 (17) | H1B—N1—H1C | 109.5 |
| N4—Co2—N3 | 90.59 (16) | O1—N8—O2$^{iv}$ | 120.3 (3) |
| N4$^{ii}$—Co2—N3 | 89.41 (16) | O1—N8—O2 | 120.3 (3) |
| N4$^{iii}$—Co2—N3 | 89.41 (16) | O2$^{iv}$—N8—O2 | 119.4 (5) |

Symmetry codes: (i) −*x*+1/2, −*y*+1/2, −*z*+1; (ii) −*x*+1, −*y*+1, −*z*; (iii) −*x*+1, *y*, −*z*; (iv) *x*, −*y*+1, *z*; (v) −*x*, −*y*+1, −*z*; (vi) −*x*, *y*, −*z*.

*Hydrogen-bond geometry (Å, º)*

| *D*—H···*A* | *D*—H | H···*A* | *D*···*A* | *D*—H···*A* |
|---|---|---|---|---|
| N1—H1*A*···Cl1 | 0.89 | 2.89 | 3.427 (4) | 120 |
| N1—H1*A*···Cl3$^{iv}$ | 0.89 | 2.90 | 3.484 (4) | 125 |
| N1—H1*B*···Cl1$^{vii}$ | 0.89 | 2.59 | 3.410 (4) | 154 |

| | | | | |
|---|---|---|---|---|
| N1—H1*C*···Cl3$^{v}$ | 0.89 | 2.63 | 3.431 (4) | 150 |
| N3—H3*A*···O2$^{viii}$ | 0.89 | 2.53 | 3.155 (6) | 128 |
| N4—H4*A*···Cl3$^{ix}$ | 0.89 | 2.79 | 3.287 (4) | 117 |
| N4—H4*B*···Cl4 | 0.89 | 2.62 | 3.448 (5) | 155 |
| N4—H4*C*···Cl2$^{ix}$ | 0.89 | 2.73 | 3.321 (4) | 125 |
| N5—H5*A*···Cl1$^{i}$ | 0.89 | 2.77 | 3.375 (4) | 127 |
| N5—H5*A*···Cl4$^{x}$ | 0.89 | 2.91 | 3.456 (4) | 122 |
| N5—H5*B*···O2$^{x}$ | 0.89 | 2.17 | 3.048 (5) | 168 |
| N5—H5*C*···Cl3$^{i}$ | 0.89 | 2.56 | 3.337 (4) | 146 |
| N6—H6*A*···Cl4$^{x}$ | 0.89 | 2.76 | 3.339 (4) | 124 |
| N6—H6*C*···Cl3$^{xi}$ | 0.89 | 2.93 | 3.445 (4) | 118 |
| N7—H7*A*···Cl4$^{viii}$ | 0.89 | 2.78 | 3.368 (4) | 125 |
| N7—H7*B*···Cl3$^{xi}$ | 0.89 | 2.87 | 3.394 (4) | 119 |

Symmetry codes: (i) −*x*+1/2, −*y*+1/2, −*z*+1; (iv) *x*, −*y*+1, *z*; (v) −*x*, −*y*+1, −*z*; (vii) −*x*, −*y*+1, −*z*+1; (viii) −*x*+1, −*y*+1, −*z*+1; (ix) *x*+1/2, *y*+1/2, *z*; (x) *x*−1/2, *y*−1/2, *z*; (xi) *x*, *y*, *z*+1.