

University of Canterbury

End-of-year Examinations 2009

Prescription Number(s): CHEM 414

Paper Title: Special Topic

Time Allowed: ONE HOUR

Number of pages: Five
plus periodic table

Answer **ALL** questions

There is a periodic table on the last page of this exam.

TURN OVER

1. (20 marks)

(a) Draw the following polyhedra and use the TEC theory to predict the electron count for each polyhedron when each vertex is occupied by a **transition metal**:

- (i) Bicapped octahedron
- (ii) Bicapped (triangular faces) trigonal prism
- (iii) Square antiprism
- (iv) Bi(trigonal prism) (sharing square faces)

(b) Using the procedure of your choice, draw or describe the probable structure of each of the following clusters:

- (i) $\text{Cu}_2\text{Rh}_6\text{C}(\text{CO})_{15}(\text{NCCH}_3)_2$
- (ii) $[\text{Os}_8(\text{CO})_{22}]^{2-}$
- (iii) $[\text{Co}_8\text{C}(\text{CO})_{18}]^{2-}$

(c) (i) What is the relationship between the number of electrons for a polyhedron with all vertices occupied by transition metal atoms and one with all vertices occupied by main group atoms?

- (ii) The cluster $[\text{Co}@Ge_{10}]^{3-}$ has been found to have a pentagonal prismatic structure. Can this be rationalised using TEC theory? Show your working.

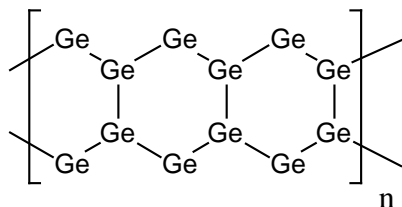
2. (10 marks)

Describe, using examples where appropriate, each of the five major classes of fluxional processes in clusters.

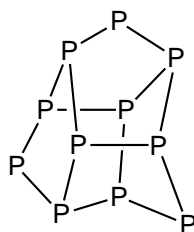
3. (20 marks)

(a) Provide the formula, including the charge, for each of the following species:

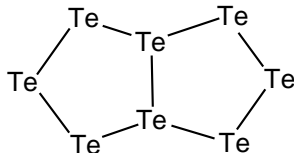
(i)



(ii)



(iii)



(b) Draw or describe the structure of each of the following molecules:

(i) $B_3C_2H_5$

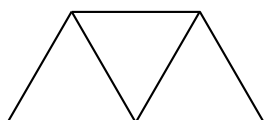
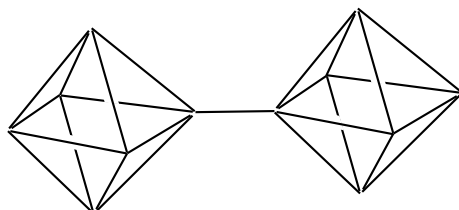
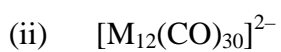
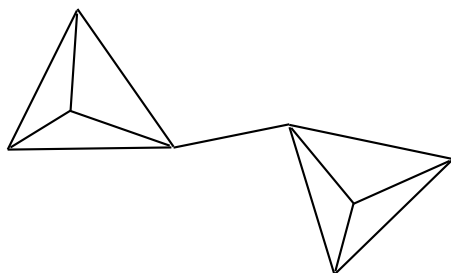
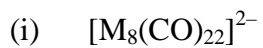
(ii) $[B_9C_2H_{11}]^{2-}$

(c) Draw all of the cage isomers for $B_3C_2H_5$.

Question 3 continued on the following page

Question 3 continued

- (d) The following clusters have been determined crystallographically, unfortunately, it is difficult to identify the metal atoms using this technique. Identify the 5d transition metal atoms in each of the following clusters (show your working).



END OF PAPER

Periodic table on following page

TURN OVER

Periodic Table

1 H 1.008																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.8	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.0	10 Ne 20.2
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc (99)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57-71 see below	72 Hf 178.5	73 Ta 181.0	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89-103 see below	104 Rf (257)	105 Db (260)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110	111	112						

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
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89 Ac (227)	90 Th 232.0	91 Pa (231)	92 U 238.1	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (245)	98 Cf (251)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lr (257)
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