28. Chemistry of transition elements

28.5 Stability constants, Kstab

Paper 4

Marking Scheme

Q1.

(a)	$K_{stab} = \frac{[[Ni(en)_3]^{2+}]}{[Ni^{2+}][en]^3}$ **OR** $\frac{[[Ni(en)_3]^{2+}]}{[Ni(H_2O)_6^{2+}][en]^3}$ [1]	**1**
(b)(i)	$[Ni(en)_3]^{2+}$ **AND** larger K_{stab} **OR** more stable [1]	**1**
(b)(ii)	$[Ni(H_2O)_6]^{2+} + 3en \rightarrow [Nien_3]^{2+} + 6H_2O$ [1]	**1**

Q2.

(c)(i)	$K_{stab} = [[Cu(CN)_4]^{3-}] / [Cu^+] [CN^-]^4$ [1] ALLOW use of $[[Cu(H_2O)_6]^+]$	**1**
(c)(ii)	$[Cu+] = 5.0 \times 10^{-19}$ (mol dm^{-3}) [1] min 1sf ECF from reversed ratio **5(c)(i)**	**1**

Q3.

(a)	equilibrium constant for the formation of a complex in a solvent **/** from its constituents [1]	**1**

(d)	$[Fe(EDTA)]^-$ **AND** largest K_{stab} [1]	**1**
(e)	$[[CuEDTA]^{2-}] \div ([[Cu(H_2O)_6]^{2+}] \times [EDTA^{2-}]) = 6.31 \times 10^{19}$ [1] 0.095 [1]	**2**

Q4.

(e)(i)	the equilibrium constant for the formation of the complex ion in a solvent (from its constituent ions or molecules)	**1**
(e)(ii)	**M1** $K_{stab} = [Ni(en)_3^{2+}] / [Ni(H_2O)_6^{2+}][en]^3$ **M1** units = mol^{-3} dm^9 ecf	**2**
(e)(iii)	the equilibria lie to the right / product side **OR** equilibrium 1 lies more to the right **AND** *en* complex is more stable / $[Ni(en)_3]^{2+}$ is more stable	**1**

Q5.

(c)(i)	the equilibrium (constant) for the formation of the complex ion in a solvent from its constituent ions or molecules	1
(c)(ii)	$[Cu(NH_3)_4(H_2O)_2]^{2+}$ AND as K_{stab} is large **OWTTE**	1
(c)(iii)	$K_{stab} = [[Cu(NH_3)_4(H_2O)_2]^{2+}] / [[Cu(H_2O)_6]^{2+}] [NH_3]^4$ [1] mol^{-4} dm^{12} [1] ecf M1	2

(c)(iv)	$[Cu(H_2O)_6]^{2+}] = (0.0074) \div (1.4 \times 10^{13} \times 0.57^4)$ $[Cu(H_2O)_6]^{2+}] =$ **5.01×10^{-15}** min 2sf ecf **6(c)(iii)**	1

Q6.

(b)(i)	the equilibrium constant for the formation of a complex ion in a solvent **OR** the equilibrium constant for the formation of a complex ion from its constituent ions	1

(b)(ii)	$K_{stab} = [[Co(NH_3)_6]^{2+}] / [[Co(H_2O)_6]^{2+}][NH_3]^6$ **or** $[[Co(NH_3)_6]^{2+}] / [Co^{2+}][NH_3]^6$	1
(b)(iii)	mol^{-6} dm^{18}	1
(b)(iv)	7.86×10^{-5}	1

Q7.

(c)(iii)	**M1:** $K_c = K_{stab} \times K_{sp} = 15.7$ **M2:** 1 **OR** none / no units	2
(d)	**M1:** highest $[Ag(CN)_2]^-$ $[Ag(S_2O_3)_2]^{3-}$ $[Ag(NH_3)_2]^+$ lowest **M2:** K_{stab} $[Ag(CN)_2]^-$ is highest / $[Ag(CN)_2]^-$ is the most stable **OR** higher K_{stab} forms the more stable complex	2

Q8.

(b)	$[[Co(NH_3)_6]^{2+}] / [[Co(H_2O)_6]^{2+}][NH_3]^6$ [1]	1
(c)	$Co(NH_3)_6^{2+}$ is more stable (than $Co(H_2O)_6^{2+}$) [1]	1

Q9.

(a)(iii)	**M1** $K_{stab1} = \frac{[[CdEDTA]^{2-}]}{[[Cd(H_2O)_6]^{2+}][EDTA^{4-}]}$ **M2** units = $mol^{-1}\ dm^3$	**2**
(b)(i)	$K_{eq4} = K_{stab3}/K_{stab2}$	**1**

Q10.

(a)(i)	Kstab = $[(Cu(NH_3)_4)^{2+}] / [(Cu(H_2O)_6)^{2+}]\ [NH_3]^4$ [1]	**1**

Q11.

(e)(i)	$[[Hg(CN)_4]^{2-}] / [Hg^{2+}][CN^-]^4$ or $[Hg(CN)_4^{2-}] / [Hg^{2+}][CN^-]^4$ [1]	**1**
(e)(ii)	concentration: highest $[Hg(CN)_4]^{2-}$ lowest $[HgCl_4]^{2-}$ [1] K_{stab} value: highest $[Hg(CN)_4]^{2-}$ lowest $[HgCl_4]^{2-}$ **OR** stability: highest $[Hg(CN)_4]^{2-}$ lowest $[HgCl_4]^{2-}$ [1]	**2**

Q12.

(d)(i)	equilibrium constant for the formation of a complex ion in solution / solvent [1]	**1**

(d)(ii)	<table><tr><th></th><th>decreases</th><th>no change</th><th>increases</th></tr><tr><td>K_{stab}</td><td>✓</td><td></td><td></td></tr><tr><td>$[[Cd(CH_3NH_2)_4(H_2O)_2]^{2+}]$</td><td>✓</td><td></td><td></td></tr></table> **M1** **both** ticks correct [1] **M2** equilibrium moves to the left as the (forward) reaction is exothermic [1]	**2**
(d)(iii)	$[CdEDTA]^{2-}$ **and** larger K_{stab} value	**1**

Q13.

(f)(i)	$K_{stab} = \frac{[Cu(H_2O)_4(NH_3)_2^{2+}]}{[Cu(H_2O)_6^{2+}][NH_3]^2}$ [1] units = $dm^6\ mol^{-2}$ [1] ecf from M1	**2**
(f)(ii)	equilibrium **4** has a (net) increase in moles of product / 2 moles goes to 3 moles whereas equilibrium **5** has same number of moles of reactants and products / 3 moles vs 3 moles [1]	**1**

(f)(iii)	$[Cu(H_2O)_4(en)]^{2+}$ **and** (equilibrium) constant / K_{stab} is the larg**est** / high**est** [1] **ALLOW** $[Cu(H_2O)_4(en)]^{2+}$ **and** constant / K_{stab} of eqm 4 is greate**r** / high**er**	**1**

Q14.

(e)(i)	$[[FeCl_4]^-] / [[Fe(H_2O)_6]^{3+}][Cl^-]^4$	**1**
(e)(ii)	0.078(125)	**1**

Q15.

(e)(i)	ligand exchange / displacement / replacement / substitution	**1**
(e)(ii)	$K_{stab} = [[CuEDTA]^{2-}] / [[Cu(H_2O)_6]^{2+}][[EDTA]^{4-}]$	**1**
(e)(iii)	stable / more stable than $[Cu(H_2O)_6]^{2+}$	**1**