Equilibria

Mark Scheme 10

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Equilibria
Sub-Topic	
Paper Type	Theory
Booklet	Mark Scheme 10

Time Allowed: **71 minutes**

Score: **/59**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** $N_2 + 2O_2 \rightarrow 2NO_2$ (*or* via NO) *or* $2NO + O_2 \rightarrow 2NO_2$ [1]

(b) **(i)** catalytic converter **and** passing the exhaust gases over a catalyst/Pt/Rh [1]

(ii) $NO_2 + 2CO \rightarrow ½ N_2 + 2CO_2$ ***or*** similar [1]
Allow $2NO_2 + CH_4 \rightarrow CO_2 + N_2 + 2H_2O$

(c) No, it wouldn't be reduced. Because the reaction in **(a)** does not presuppose a particular fuel (owtte) [1]
Allow formed from N_2 and O_2 in air during combustion

(d) **(i)** SO_3 produces acid rain [1]

(ii) $NO + ½ O_2 \rightarrow NO_2$ [1]

(iii) $K_p = (p_{NO}.p_{SO_3})/(p_{NO_2}.p_{SO_2})$ [1

units: dimensionless/none (don't accept just a blank!) [1]

(iv) $K_p = 99.8^2/0.2^2 =$ **2.5×10^5** [1]

(v) It will shift to the right (owtte) [1]
because the reaction is exothermic. NOT just Le Chatelier argument [1]

[Total: 11]

2 **(a** hydrogen bonding (1)

diag: $NH_2CH_2CH_2OH$---$OHCH_2CH_2NH_2$ *or* $NH_2CH_2CH_2OH$---$NH_2CH_2CH_2OH$
(i.e. H-bond from OH group to either OH or NH_2) (1 [2]

(b) propylamine is more basic than phenylamine (1)
because lone pair on N is delocalised over ring in phenylamine (so less available for protonation)
or the propyl group is electron-donating, so the lone pair is more available (1) [2]

(c) $HOCH_2CH_2NH_2 + H^+ \longrightarrow HOCH_2CH_2NH_3^+$
or $HOCH_2CH_2NH_2 + HCl \longrightarrow HOCH_2CH_2NH_3^+Cl^-$
or $HOCH_2CH_2NH_2 + H_2O \longrightarrow HOCH_2CH_2NH_3^+OH^-$
(reaction with any acceptable Bronsted acid accepted) [1]

(d) **(** **X** is CH_3CH_2CN (

(ii) step 1 is KCN in ethanol, heat [HCN negates] (1)
step 2 is H_2+Ni / Pt or $LiAlH_4$ or Na in ethanol [NOT $NaBH_4$ or Sn/HCl] (1) [3]

(e) ethanolamine:

Na		effervescence / bubbles produced	
or $Cr_2O_7^{2-}$ / H^+		colour turns from orange to green	
or MnO_4^- / H^+		purple colour disappears	
or PCl_3 / PCl_5 / $SOCl_2$	(1)	steamy fumes	(1)

phenylamine:

Br_2(aq)		decolourises / white ppt formed	
or HNO_2 / H^+ at T<10°C, then phenol in NaOH	(1)	coloured dye formed	(1) [4]

[Total: 12]

3 **(a) (i)** Br_2 (ignore solvent, but do not credit $AlCl_3$ or HCl or light) (1)

(ii) curly arrow from C=C to Br (1)
another one breaking Br-Br bond. (1)
correct intermediate cation and Br^- produced (not $Br^{\delta-}$) (1) **[max 3]**

(b) **B** is $NH_2CH_2CH_2NH_2$ (1)
C is $NCCH_2CH_2CN$ (1)
E is $ClCOCH_2CH_2COCl$ (1) **[3]**
(Allow $(CH_2)_2$ or C_2H_4. Allow correct atoms in any order on LHS but order must be correct on RHS)

(c) reaction **II**: heat, dilute H^+(aq) or HCl(aq) or HCl(conc) or H_2SO_4(aq) (1)
reaction **III**: H_2 + Ni (or other named catalyst) or $LiAlH_4$ or Na in ethanol (1) **[2]**

(d) NH_4^+ (1) **[1]**

(e) (i) [-$NHCH_2CH_2CH_2CH_2NH$-$COCH_2CH_2CO$-] (1)
(allow $(CH_2)_4$ and $(CH_2)_2$)
(**not** dimer, needs bonds both ends)

(ii) HCl (1) **[2]**

(f) (i) $[H^+] = 10^{-pH} = 10^{-2.6} = 2.51 \times 10^{-3}$ (mol dm^{-3}) (1)

(ii) $Ka = [H^+]^2/c = 6.31 \times 10^{-5}$ (mol dm^{-3}) (allow ecf from **(i)**) (1) **[2]**

[Total: 13]

4 **(a (i)** Partition coefficient (PC) is an equilibrium constant representing the distribution of a solute between two solvents.
or PC = ratio of the concentrations of the solute in the two solvents *or* PC = $[X]_a/[X]_b$
[1]

(ii) If 0.4 g has been extracted, 0.1 g remain in the aqueous layer.

the concentration in the hexane layer = $\frac{0.4}{20}$ = 0.02 g cm^{-3}

the concentration in the aqueous layer = $\frac{0.1}{100}$ = 0.001 g cm^{-3}

K_{pc} = 0.02/0.001 = **20** [1]

(iii) *1st extraction*: hexane *x*/10 g cm^{-3} water (0.50-*x*)/100 g cm^{-3}

$K_{pc} = \frac{x/10}{(0.5 - x)/100} = 20$

hence $x/10 = (10 - 20x)/100$

$100x = 10(10 - 20x)$ or $100x = 100 - 200x$

***x* = 0.33 g** [1]

2nd extraction: hexane *y*/10 g cm^{-3} water (0.17 – *y*)/100 g cm^{-3}

$K_{pc} = \frac{y/10}{(0.17 - y)/100} = 20$

hence $y/10 = (3.4 - 20y)/100$

$100y = 10(3.4 - 20y)$ or $100y = 34 - 200y$

***y* = 0.11 g** [1]

total extracted = **0.44** g, *or* difference = **0.04** g *or* **10% more** (is extracted) [1]
(correct answer = [3]) **[5]**

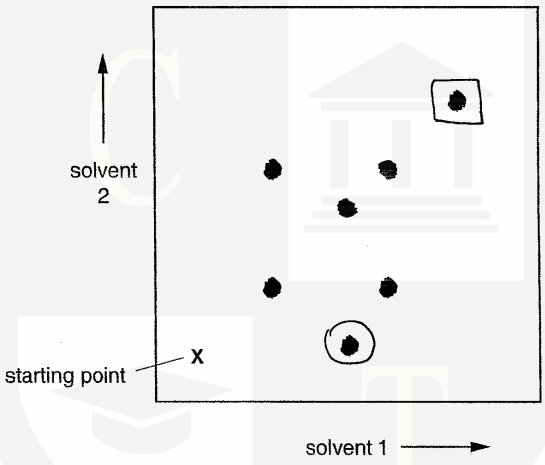
(b) berries are aqueous media [1]
PCBs are insoluble/sparingly soluble in water *or* more fat-soluble [1]

(ii) partition coefficient *or* [fat]/[water] is greater than 1 [1]

[3]

(c) **(i)** 4 (four) [1]

(ii)



correct spot circled [1]
correct spot squared [1]
[in each case, more than one spot circled or squared negates the mark] **[3]**

[Total: 11]

5 **(a** d-orbitals split into two / different levels
light is absorbed
electron is promoted from a lower to a higher level
colour observed is the complement of the colour absorbed
$E = hf$ any 3 points [3]
[3]

(b) $[Cu(H_2O)_6]^{2+}$ is pale blue [1]
$[Cu(NH_3)_4(H_2O)_2]^{2+}$ is deep / dark blue *or* purple [1]

(ii) because it has a larger absorbance peak *or* a larger ε_o value [1]
because λ_{max} is in the visible region (hence more visible light is absorbed) [1]

(iii) curve will have λ_{max} between >600 nm and 800 nm [1]
with maximum ε_o in between the other two [1]
[6]

(c) $K_c = [CuCl_4^{2-}]/([Cu^{2+}][Cl^-]^4)$ units are $mol^{-4}\ dm^{12}$ [1] + [1]

(ii) $[CuCl_4^{2-}]/[Cu^{2+}] = K_c[Cl^-]^4 = 672$ (no units) [1]
[3]

[Total: 12]