Equilibria

Mark Scheme 4

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Equilibria
Sub-Topic	
Paper Type	Theory
Booklet	Mark Scheme 4

Time Allowed: **64 minutes**

Score: **/53**

Percentage: **/100**

Grade Boundaries:

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

1 **(a) (i)** $C_2H_5NH_2 + HA \rightarrow C_2H_5NH_3^+ + A^-$ (HA can be H_2O, HC*l* etc.) [1]
Allow $\rightleftharpoons$ instead of arrow

(ii)

most basic		least basic
ethylamine		**phenylamine**

[1]

(iii) ethylamine > NH_3 due to electron-donating ethyl/alkyl group [1]
phenylamine < NH_3 due to delocalisation of lone pair over ring [1]
[4]

(b) (i) $C_6H_5OH + OH^- \rightarrow C_6H_5O^- + H_2O$ (*or* with $Na^+/H_2O/A^-$) [1]

(ii) pKa of nitrophenol is smaller/K_a is larger because it's a stronger acid/dissociates more than phenol [1]
stronger because the anionic charge is spread out moreover the NO_2 group *or* NO_2 is electron-withdrawing [1]

(iii) pKa = 1.0 [1]

(iv) Nitro group increases acidity / electron-withdrawing groups increase acidity [1]
[5]

(c) (i) **B** is phenyldiazonium cation, $C_6H_5–N^+\equiv N$ [1]

(ii)

reaction	re	conditions
Step 1	**$NaNO_2$ + HC*l* or HNO_2** [1]	**T < 10°C** [1]
Step 2	**H_2O / aq**	**heat/boil/T > 10°** (both) [1]
Step 3	**HNO_3 NB HNO_3(aq) OK for both**	**dilute** (both) [1]

[4]
[5]

[Total: 14]

2 **(a)** $N_2 + 3H_2 \rightleftharpoons 2NH_3$ (1)

(b) temperature between 300 and 550°C (1)

correct explanation of effect of temperature on
rate of formation of NH_3 **or** on position of equilibrium (1)

catalyst of iron **or** iron oxide (1)

to speed up reaction **or** to reduce E_a (1)

(c) manufacture of HNO_3
or explosives
or nylon
or as a cleaning agent
or as a refrigerant (1) [1]

(d) fertiliser in rivers causes excessive growth of aquatic plants/algae (1)

when plants and algae die O_2 is used up/fish or aquatic life die (1) [2]

(e) **(** CO by incomplete combustion of the hydrocarbon fuel (1)

NO by reaction between N_2 and O_2 in the engine (1)

(ii) CO toxic/effect on haemoglobin (1)

NO toxic/formation of acid rain (1) [4]

(f) **(** platinum/Pt – allow palladium/Pd **or** rhodium/Rh (1)

(ii) $2CO + 2NO \rightarrow 2CO_2 + N_2$ (1) [2]

[Total: 14]

3 **(a) (** A few nanometres (accept 0.5–10 nm) (1)

(ii) Graphite/graphene (1)

(iii) van der Waals' (1)
Carbon atoms in the nanotubes are joined by covalent bonds (1)
(as are the hydrogen atoms in a hydrogen molecule)
or no dipoles on C or H_2 *or* the substances are non-polar **[4]**

(b) More hydrogen can be packed into the same space/volume (1) **[1]**

(c) If a system at equilibrium is disturbed, the equilibrium moves in the direction which tends to reduce the disturbance (owtte) (1)

When H_2 is removed the pressure drops and more H_2 is released from that adsorbed (1)

The equilibrium $H_{2adsorbed} \rightleftharpoons H_{2gaseous}$ (1)

Equilibrium shifts to the right as pressure drops (1) **[4]**

[Total: 9]

4 **(a) (i)** $P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$ (or similar) or $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$ (1)
$SO_2 + H_2O \rightarrow H_2SO_3$ (1)

(ii) $2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$ (1)

(iii) $2ClO_2 + 2NaOH \rightarrow NaClO_2 + NaClO_3 + H_2O$ or ionic eqn (1) **[4]**

(b) (i) $2CH_4 + C_2H_6 + H_2S + 9O_2 \rightarrow 4CO_2 + SO_2 + 8H_2O$
Formulae (1), balanced (1)

(ii) (The SO_2 produced) causes acid rain (1)
or consequence of acid rain – defoliation etc. – or respiratory problem

(iii) 1000 dm^3 contains 50 dm^3 of H_2S
this is 50/24 (= **2.083** moles) (1)
M_r(ethanolamine) = 24 + 7 + 14 + 16 = **61**
therefore mass = 2.083 × 61 = **127(.1)**g (1) (or ecf)

(iv) acid-base (1)

(v) $\Delta H = \Delta H_f(rhs) - \Delta H_f(lhs)$
= {(3 × 11 – 2 × 242)}{–}{(2 × –21 – 297)} –1 for each { } in which there is an error
= –451 + 339
= –112 (kJ mol^{-1}) (2) **[8]**

[Total: 12]

5 **(a)** $NH_2CH_2CH_2CH_2NH_2 + HCl \rightarrow NH_2CH_2CH_2CH_2NH_3^+ Cl^-$ (1)
$NH_2CH_2CH_2CH_2NH_3^+ Cl^- + HCl \rightarrow Cl^- NH_3{+}CH_2CH_2CH_2NH_3^+ Cl^-$ (1) **[2]**
(Deduct 1 only, if Cl^- omitted twice but allow with H^+)

(b) starts at 11.3 and finished as 1.6 (1)
steep portions at 10 cm^3 and 20 cm^3 volume added (1) **[2]**

[Total: 4]