Equilibria

Mark Scheme 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Equilibria
Sub-Topic	
Paper Type	Theory
Booklet	Mark Scheme 2

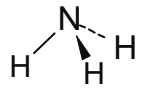
Time Allowed: **65 minutes**

Score: **/54**

Percentage: **/100**

Grade Boundaries:

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

Question	Scheme	Marks	T
1 **(a)**	$CH_4 + H_2O \rightarrow CO + 3H_2$	1	[1
(b)	Label on graph indicating catalysed and uncatalysed Ea OR statement Ea catalysed is lower (than Ea uncatalysed) owtte Reference to catalyst creating alternative mechanism / reaction pathway / route Idea that more molecules have sufficient energy (to react) so greater chance / frequency of successful collisions	1 1 1 1	 [4]
(c)	 angle = 107° shape = (trigonal) pyramid(al)	1 1 1	 [3]
(d) (i)	Advantage = higher rate Greater Kinetic Energy / speed / collision frequency / proportion of successful collisions Disadvantage – reduced yield / less product / more reactants (Forward reaction) **exothermic AND** (hence in accordance with Le Chatelier's Principle) equilibrium / reaction **shifts left** (to counteract increasing temp) ora	1 1 1 1	 [4]
(ii)	$K_p = \frac{pNH_3^{\,2}}{pN_2 \times pH_2^{\,3}}$	1	[1]

(iii)	$N_2(g)$ + $3H_2(g) \rightleftharpoons 2NH_3(g)$ 2 3 0 (–0.8) (–1.6×3/2) 1.2 0.6 1.60 xNH_3 = 1.6/3.4 (= 0.471) xN_2 = 1.2/3.4 (= 0.353) xH_2 = 0.6/3.4 (= 0.176) $K_p = \frac{0.471^2 \times \cancel{(2 \times 10^7)^2}}{0.353 \times 2 \times 10^7 \times 0.176^3 \times \cancel{(2 \times 10^7)^3}} = 2.88 \times 10^{-13}\ Pa^{-2}$	1 1 1+1	[5]
			[18]

2 **(a** a base is a proton acceptor **or**
a lone pair donor (1)
a weak base is not fully ionised (1)
e.g. $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ **or**
$B + H^+ \rightleftharpoons BH^+$ **or** equivalent
$\rightleftharpoons$ is necessary (1) [3]

(b) **(** **stated** pressure greater than 1 atm up to 5 atm (1)
stated temperature 400 to 500 °C (1
named catalyst V_2O_5/vanadium(V) oxide (1)

(ii) SO_3 is dissolved in concentrated H_2SO_4
and then diluted with water
not 'SO_3 dissolved in water' as the only statement (1) [4]

(c) **(i)** **with concentrated sulfuric acid**
$ClCH_2CH=CHCl$ (1)

with ammonia
$H_2NCH_2CH(OH)CH_2NH_2$ (1)

(ii) nucleophilic (1)
substitution (1) [4]

[Total: 11]

3 **(a) (i)** if the conditions of a system in equilibrium are changed (1)

the position of equilibrium moves so as to reduce that change (1) [2]

(ii) lower temperature (1)

because the forward reaction is exothermic (1)

higher pressure (1)

because the forward reaction shows a reduction in volume
or
there are fewer molecules/moles on RHS of equilibrium (1) [4]

(b)

	CO_2	+	$_2$	⇌	CO	+	$_2O$	
initial moles	0.70		0.70		0.30		0.30	
equil. moles	(0.70–x)		(0.70–x)		(0.30+x)		(0.30+x)	(1)
equil. concn.	$\frac{(0.70-x)}{1}$		$\frac{(0.70-x)}{1}$		$\frac{(0.30+x)}{1}$		$\frac{(0.30+x)}{1}$	

$K_c = \frac{(0.30+x)^2}{(0.70-x)^2} = 1.44$ (1)

gives x = 0.25 (1)
at equilibrium,
$n(CO_2) = n(H_2) = 0.70 - 0.25 = 0.45$ moles
and
$n(CO) = n(H_2O) = 0.3 + 0.25 = 0.55$ moles (1) [4]

[Total: 10]

4 **(a** (due to the) strong N≡N bond [1]
[1]

(b) **(** Any balanced equation forming a stable nitrogen oxide
e.g. $N_2 + O_2 \longrightarrow 2NO$
or
$N_2 + 2O_2 \longrightarrow 2NO_2$ [1]

(ii) in lightning [1]

in an engine/combustion of fuels (or a specific example) [1]

(iii) (NO_x produces) acid rain *or* forms (photochemical) smog [1]
[4]

(c) (base is a) proton acceptor [1]

basicities: ethylamine > NH_3 > phenylamine [1]

ethylamine (more basic) due to electron donating ethyl group [1]

phenylamine (less basic) due to lone pair being delocalised into the ring [1]
[4]

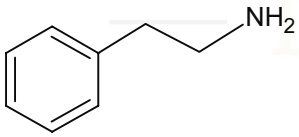
(d) **(** step 1: nucleophilic substitution [1]

step 2: hydrolysis [1]

(ii) step 1: KCN (in ethanol) **and** reflux [1]

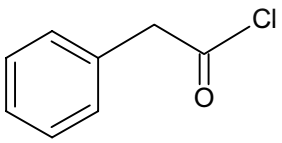
step 2: H_3O^+ / aqueous acid **and** reflux [1]

(iii) **T** is



[1]

W is



[1]
[6]

[Total: 15]