Equilibria

Mark Scheme 9

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Equilibria
Sub-Topic	
Paper Type	Theory
Booklet	Mark Scheme 9

Time Allowed: **63 minutes**

Score: **/52**

Percentage: **/100**

Grade Boundaries:

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

1 **(a (i)** thermal stability decreases down Group VII (1)

(ii) from C*l* to I, atomic size increases **or**
the bonding pair is further from the nucleus of X **or**
H—X bond becomes longer **or**
smaller orbital overlap occurs (1)
hence H—X bond strength decreases down Group VII (1) [3]

(b) $K_c = \dfrac{[HI]^2}{[H_2]\times[I_2]}$ (1)

no units – must be clearly stated (1) [2]

(c) (no change (1)
K_c has no units **or**
same no. of molecules / moles each side of equilibrium (1)

(ii) equilibrium moves to RHS (1)
K_c increases with decreasing temperature **or**
forward reaction is exothermic **or**
reverse reaction is endothermic (1) [4]

(d)

	$H_2(g)$	$I_2(g)$	$\rightleftharpoons$	$2HI(g)$	
initial moles	0.02	0.02		0	
equil. moles	(0.02 – y)	(0.02 – y)		2y	(1)
equil. conc/mol dm^{-3}	$\frac{(0.02-y)}{1}$	$\frac{(0.02-y)}{1}$		$\frac{2y}{1}$	

$K_c = \dfrac{HI^2}{[H_2]\times[I_2]} = \dfrac{(2y)^2}{(0.02-y)^2} = 59$ (1)

$\dfrac{2y}{(0.02-y)} = \sqrt{59} = 77$

2y = (7.7 × 0.02) – 7.7y

9.7y = 0.154

gives $y = \dfrac{0.154}{9.7} = 0.0159 = 0.016$ (1)

at equilibrium

$n(HI) = 2 \times 0.016 = 0.032$ **and**
$n(H_2) = n(I_2) = (0.02 - 0.016) = 0.004$ (1)

allow ecf where possible [4]

[Total: 13]

2 **(a** manufacture of ammonia/Haber process **or** hydrogenation of fats/oils **or** making margarine **or** hydrocracking (1) [1]

(b) **increasing the pressure**
equilibrium will move to LHS (1)
fewer moles/molecules on LHS or more moles/molecules on RHS (1)

(ii) **decreasing the temperature**
equilibrium will move to LHS (1)
forward reaction is endothermic (1) [4]

(c) rate will increase (1)
collisions will occur more frequently (1) [2]

(d) **(i)** $K_c = \dfrac{[CO_2][H_2]}{[CO][H_20]}$ (

(ii)

	$CO(g)$	+ $H_2O(g)$	⇌ $CO_2(g)$	+ $H_2(g)$
initial moles	0.40	0.40	0.20	0.20
equil moles	(0.40 – y)	(0.40 – y)	(0.20 + y)	(0.20 + y)
equil concn./mol dm^{-3}	$\frac{(0.40 - y)}{1}$	$\frac{(0.40 - y)}{1}$	$\frac{(0.20 + y)}{1}$	$\frac{(0.20 + y)}{1}$

$K_c = \dfrac{(0.20 + y)^2}{(0.40 - y)^2} = 6.40 \times 10^{-1}$ (1)

$\dfrac{(0.20 + y)}{(0.40 - y)} = \sqrt{6.40 \times 10^{-1}} = 0.8$

$(0.20 + y) = 0.8 \times (0.40 - y)$

$0.20 + y = 0.32 - 0.8y$

$1.8y = 0.12$

gives y = 0.067 (1)

at equilibrium

$n(CO) = n(H_2O) = (0.40 - 0.067) = 0.33$ mol **and**
$n(CO_2) = n(H_2) = (0.20 + 0.067) = 0.27$ mol

allow ecf as appropriate [5]

[Total: 12]

3 **(a (i)** break large hydrocarbons into smaller hydrocarbons **or** break down large hydrocarbons (1)

smaller hydrocarbons are more useful **or** smaller hydrocarbons are more in demand (1)

(ii) using high temperatures/thermal cracking **or** using catalysts/catalytic cracking (1)

(iii) $C_{14}H_{30} \rightarrow C_7H_{16} + C_7H_{14}$ **or**
$C_{14}H_{30} \rightarrow C_7H_{16} + C_2H_4 + C_5H_{10}$ **or**
$C_{14}H_{30} \rightarrow C_7H_{16} + C_3H_6 + C_4H_8$ **or**
$C_{14}H_{30} \rightarrow C_7H_{16} + 2C_2H_4 + C_3H_6$ (1)

do not allow any equation with H_2 [4]

(b) ethanol has hydrogen bonding, ethanethiol does not (1) [1]

(c) $C_2H_5SH + \mathbf{^9/_2}\,O_2 \rightarrow \mathbf{2}CO_2 + SO_2 + \mathbf{3}H_2O$ **or**
$\mathbf{2}C_2H_5SH + \mathbf{9}O_2 \rightarrow \mathbf{4}CO_2 + \mathbf{2}SO_2 + \mathbf{6}H_2O$
correct products (1)
correct equation which is balanced (1)

(ii) **for CO_2**
enhanced greenhouse effect (1)
global warming (1)

for SO_2
formation of acid rain (1)
damage to stonework of buildings/
dissolving of aluminium ions into rivers/
damage to watercourses or forests/
aquatic life destroyed/
corrosion of metals (1) [6]

(d) help detect leaks of gas (1) [1]

(e) temperature of 450°C (1)
pressure of 1 – 2 atm (1)
V_2O_5/vanadium(V) oxide/vanadium pentoxide catalyst [3]

[Total: 15]

4 **(a)** N≡N triple bond is (very) strong
or the N_2 molecule has no polarity [1]

(b) $3Mg(s) \rightarrow 3Mg^{2+}(g)$ $\Delta H_1 = 3 \times 148 + 3 \times 2186 = 7002$
$N_2(g) \rightarrow 2N^{3-}(g)$ $\Delta H_2 = 994 + 2 \times 2148 = 5290$

LE = $-\Delta H_1 - \Delta H_2 - 461$ = **–12,753** (kJ mol^{-1}) (–[1] for each error) [3]

(c) **(i)** $Li_3N + 3H_2O \rightarrow NH_3 + 3LiOH$ (balanced equation) [1]

(ii) advantage: no high pressure/temperature/catalyst needed/standard conditions used [1]

disadvantage: Li is expensive
or Li would need to be recycled/removed
or LiOH by-product is corrosive/strongly basic
or this would be a batch, rather than continuous process [1]

(d) **(i)** Li_3N: 100 × 14/35 = 40% N [1]
urea: 100 × 28/60 = 47% N [1]

(ii) amide [1]

(iii) $NH_2CONH_2 + H_2O \rightarrow 2NH_3 + CO_2$
or $\rightarrow NH_2CO_2H + NH_3$
or $NH_2CONH_2 + 2H_2O \rightarrow 2NH_3 + H_2CO_3$ [1]

(iv) The LiOH would be strongly alkaline
or would increase the pH of the soil
or would 'burn' the crops/reduce plant growth/stunt plants
or would contaminate the environment [1]

[Total: 12]