CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2012 series

9701 CHEMISTRY

9701/21 Paper 2 (AS Structured Questions), maximum raw mark 60

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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International Examinations

1 **(a)** $ZnCO_3$ $Zn(OH)_2$ ZnO
not Zn **or** other compounds of Zn (any 2) [2]

(b) **(i)** to ensure all of the water of crystallisation had been driven off **or** to be at constant mass (1)

(ii) mass of $ZnSO_4$ = 76.34 – 74.25 = 2.09 g (1)

M_r $ZnSO_4$ = 65.4 + 32.1 + (4 × 16.0) = 161.5

allow use of Zn = 65 and/or S = 32 to give values between 161 and 161.5 (1)

$n(ZnSO_4) = \frac{2.09}{161.5} = 0.01294 = 1.29 \times 10^{-2}$

$ZnSO_4$ = 161 gives 1.30×10^{-2} (1)

(iii) mass of H_2O driven off = 77.97 – 76.34 = 1.63 g (1)

$n(H_2O) = \frac{1.63}{18} = 0.0905 = 9.1 \times 10^{-2}$ (1)

(iv) 1.29×10^{-2} mol $ZnSO_4$ are combined with 9.1×10^{-2} mol H_2O

1 mol $ZnSO_4$ is combined with $\frac{9.1 \times 10^{-2}}{1.29 \times 10^{-2}}$

= 7.054 ≡ 7 mol H_2O

answer must be expressed as a whole number
allow ecf on candidate's answers to **(b)(ii)** and **(b)(iii)** (1) [7]

(c) **(i)** $n(Zn) = n\ (CH_3CO_2)_2Zn.2H_2O$ (1)

$n(Zn) = \frac{0.015}{65.4} = 2.290 \times 10^{-4}$

$= 2.29 \times 10^{-4}$ (1)

mass of crystals = $2.29 \times 10^{-4} \times 219.4 = 0.0502655$ g
= 0.05 g = 50 mg (1)

(ii) concentration of $(CH_3CO_2)_2Zn.2H_2O = \frac{2.29 \times 10^{-4}}{0.005} = 0.0458$
$= 4.58 \times 10^{-2}$ mol dm^{-3} (1)

allow correct answers if Zn = 65 is used [4]

[Total: 13]

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

(ii) from Cl 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) (i) 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)

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

(1)

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

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

$2y = (7.7 \times 0.02) - 7.7y$

$9.7y = 0.154$

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]

3 (a) (i) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ **or**
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

state symbols required (1)

(ii) pressure between 60 and 250 atm **or**
between 60 × 10^5 Pa and 250 × 10^5 Pa (1)

temperature between 300 and 550 °C (1)

catalyst iron / iron oxide (1)

(iii) manufacture of HNO_3 / as a cleaning agent / refrigerant / fertiliser / manufacture of fertilisers / explosives / to remove SO_2 from combustion products of hydrocarbon fuels (1) [5]

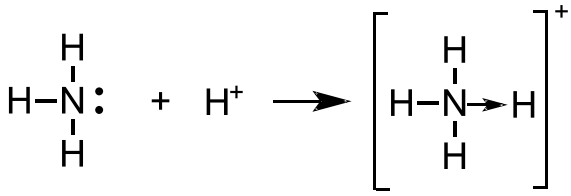
(b) (i) NH_4Cl **and** $Ca(OH)_2$
both formulae required (1)

(ii) $2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2NH_3 + 2H_2O$ **or**
$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$

correct products (1)
correctly balanced equation (1)

(iii) CaO (1)
it is not an acid / it is basic / it does not react with NH_3 **or**
both P_2O_5 / P_4O_{10} **and** H_2SO_4 are acidic / react with NH_3 (1) [5]

(c)



correct displayed eqn.,
with positive charge clearly shown (1)
lone pair on NH_3 (1)
co-ordinate / dative bond clearly shown (1) [3]

[Total: 13]

4 (a) (i)

reaction	organic compound	reagent	structural formulae of organic products
A	$(CH_3)_3COH$	$Cr_2O_7^{2-}/H^+$ heat under reflux	no reaction
B	CH_3CH_2CHO	Fehling's reagent warm	$CH_3CH_2CO_2H$ **or** $CH_3CH_2CO_2^-$
C	$HCO_2CH(CH_3)_2$	NaOH(aq) warm	HCO_2Na **or** HCO_2^- $(CH_3)_2CHOH$
D	$CH_2=CHCHO$	$NaBH_4$	$CH_2=CHCH_2OH$
E	$(CH_3)_3COH$	$NaBH_4$	no reaction
F	$CH_3CH_2COCH_3$	MnO_4^-/H^+ heat under reflux	no reaction

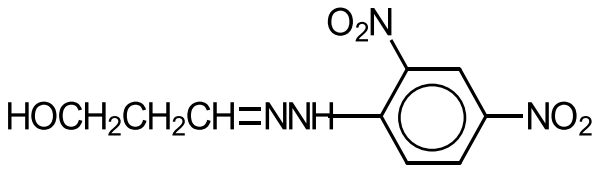
each correct answer gets (1) (7 × 1)

(ii)

reaction	colour at the beginning of the reaction	colour at the end of the reaction
B	blue	brick red

each correct answer gets 1 (1 +1 + 1) [10]

(b) (i)



(1)

(ii) red **or** orange (1) [2]

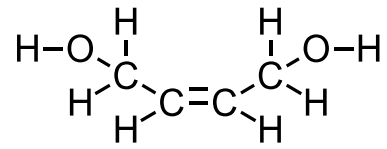
[Total: 12]

5 (a) (i) carboxylic acid **or** alcohol present **or**
carboxylic acid **and** alcohol present
not acid **or** carboxyl **or** hydroxyl (1)

(ii) carboxylic acid **not** present **or**
only alcohol present (1)

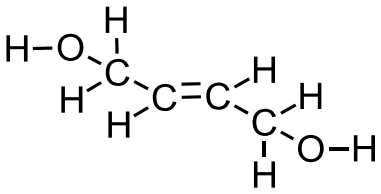
(iii) alkene **or** >C=C< present (1) [3]

(b) (i)



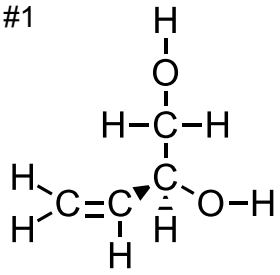
each correct structure gets (1) (4 × 1)

(ii) pair 1 geometrical **or** *cis-trans* **or** *E*/*Z* isomerism (1)

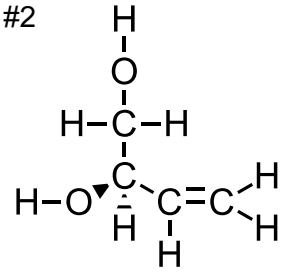


pair 2 optical isomerism – accept chiral compounds (1) [6]

#1



#2



[Total: 9]