UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2012 question paper

for the guidance of teachers

9701 CHEMISTRY

9701/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

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 must be read in conjunction with the question papers and the report on the examination.

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UNIVERSITY of CAMBRIDGE
International Examinations

1 (a) (i) the enthalpy change/released when **1 mole is formed** [1]

of ionic lattice **from** the **gas** phase **ions** [1]

(ii) $Mg^{2+} + O^{2-} \longrightarrow MgO$ [1]
[3]

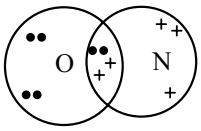
(b) measurements needed:
volume/mass/weight of water (in calorimeter) [1]
initial + final temperature/temperature change/temperature rise (of the water) [1]
mass of Mg (used)/mass MgO [1]
Not *volume/moles/mass of oxygen used*
[3]

(c) $\Delta H = 148 + 736 + 1450 + 496/2 - 141 + 798 - 3791$
= –552 kJ mol^{-1} [3]
[3]

(d) $Na_2O(s) + H_2O(aq/l) \longrightarrow 2NaOH(aq)$ [1]
$MgO(s) + H_2O(aq/l) \longrightarrow Mg(OH)_2(s)$ *or* $Mg(OH)_2(aq)$ [1]
pH 12.5-14 [NaOH] **AND** 8-10.5 [$Mg(OH)_2$] respectively [1]
[3]

[Total: 12]

2. (a) (i)



[1]

(ii) –180 kJ mol^{-1} [1]

(iii) (formation of NO is endothermic) so high T **and** equilibrium pushed over to NO side.
or high T **and** needed to break N-N bond in N_2 [1]

(iv) –180 = 2 E(NO) – 994 – 496 [1]
E(NO) = **+655 kJ mol^{-1}** [1]
[5]

(b) (i) (from 1 and 2:) as p(NO) halves, rate decreases to ¼ , **so order = 2** [1]
(from 1 and 3:) as $p(H_2)$ halves, so does rate, **so order = 1** [1]

(ii) rate = $k\ p_{NO}^2.p_{H2}$ [1]
units (of k) are $atm^{-2}\ s^{-1}$ [1]

(iii) add all three equations:
$NO + NO + H_2 + O + H_2 + N_2O \rightarrow N_2O + O + H_2O + N_2 + H_2O$ [1]
cross out all species common to both sides:
$NO + NO + H_2 + \cancel{O} + H_2 + \cancel{N_2O} \rightarrow \cancel{N_2O} + \cancel{O} + H_2O + N_2 + H_2O$ [1]
($\Rightarrow \quad 2NO + 2H_2 \rightarrow N_2 + 2H_2O$)

(iv) *either*: **step 2** since it involves H_2 [1]
O formed from NO [1]
or: ***step 3*** *since it involves* H_2 *[1]*
N_2O *formed from NO* *[1]*
[8]

(c) (i) NO [1]

(ii) $3Fe^{2+} + 4H^+ + NO_3^- \longrightarrow 3Fe^{3+} + NO + 2H_2O$ [1]
(allow $Fe^{2+} + H^+ + HNO_2 \longrightarrow Fe^{3+} + NO + H_2O$)

(iii) dative/coordinate bonding [1]

(iv) $[Fe(H_2O)_{6-n}(NO)_n]^{2+}$ (n = 1-6) [1]
[4]

[Total:17]

3. (a) (i) $C_{16}H_{10}N_2O_2$ [1]

(ii) ketone, alkene, amine, aryl (benzene/arene/phenyl) (**any 3**) [2]
[3]

(b) (i) reduction *or* redox [1]

(ii) $NaBH_4$ or $LiAlH_4$ (**NOT** H_2 + Ni) [1]
[2]

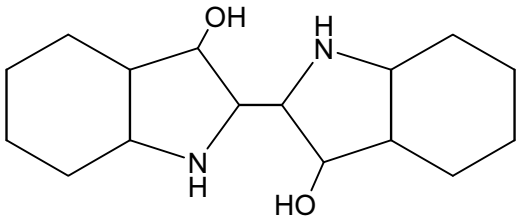
(c) 1. 2,4-DNPH [1] red/yellow-orange/orange ppt. [1] no reaction

2. Na metal [1] no reaction gas given off/fizzing [1]

or $PCl_5/SOCl_2$ *[1]* *no reaction* *steamy fumes/fizzing* *[1]*
or PCl_3 *+ warm* *misty/white fumes*

2 x "no reaction" must be linked to "correct reagent" [1]
[5]

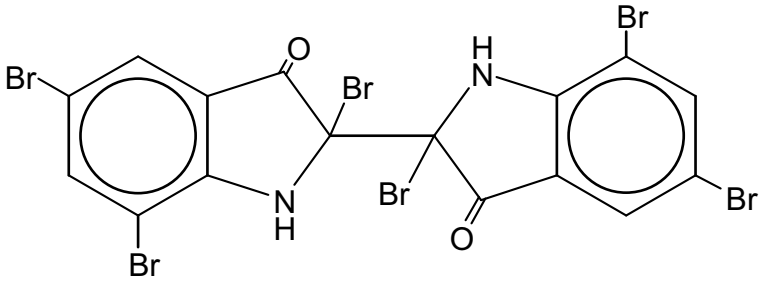
(d) (i)



[1]

(ii) M_r = 262, so 2.5 g = 2.5/262 = 9.54×10^{-3} mol [1]
(1 mol indigo absorbs 9 mol of H_2)
so volume of $H_2 = 9 \times 24 - 9.54 \times 10^{-3}$ = **2.06 dm^3** (2060 cm^3)
[1]
[3]

(e)



2 x Br **on C=C** [1]
a Br on each ring [1]
TWO non-adjacent Br on **each ring** [1]
[3]

[Total: 16]

4 (a) (i) volatilities decrease down the group [1]

due to greater van der Waals (VDW) forces (*intermolecular is not sufficient*) [1]

due to larger no of electrons [1]

(ii) CCl_4 does not react with water [1]

CCl_4 unreactive due to no **d**-orbitals [1]

$GeCl_4$ **and** $PbCl_4$ hydrolyse/react [1]

$MCl_4 + 2H_2O \longrightarrow MO_2 + 4HCl$ (M = Ge *or* Pb) [1]
[7]

(b) (i) **B** is $PbSO_4$ **and C** is $PbCl_2$ [1]

(ii) $SnO_2 + 2H_2SO_4 \longrightarrow Sn(SO_4)_2 + 2H_2O$ [1]

$PbO_2 + H_2SO_4 \longrightarrow PbSO_4 + H_2O + ½\ O_2$ [1]

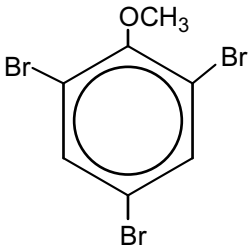
$PbO_2 + 6HCl \longrightarrow H_2PbCl_6 + 2H_2O$ [1]

$H_2PbCl_6 \longrightarrow PbCl_2 + 2HCl + Cl_2$ [1]

[5 max 4]

[Total: 11]

5 (a) (i)

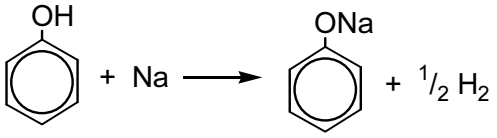


[1]

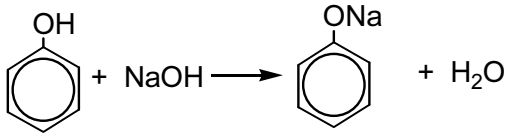
(ii) Na metal *or* NaOH [1]

Fizzes/gas given off with phenol *or* phenol dissolves (anisole doesn't) [1]

$C_6H_5OH + Na \rightarrow C_6H_5ONa + ½\ H_2$ *or* $C_6H_5OH + OH^- \rightarrow C_6H_5O^- + H_2O$ [1]



or



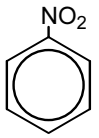
(neutral) iron(III) chloride *[1]*

Solution goes purple/violet *[1]*

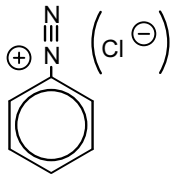
$3C_6H_5OH + FeCl_3 \rightarrow Fe(OC_6H_5)_3 + 3HCl$ *[1]*

[4]

(b) (i)



D



E

[1] + [1]

(ii) step 2: Sn **+** HCl **NOT** $LiAlH_4$, $NaBH_4$ [1]

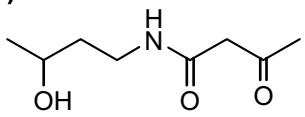
conc. **+** reflux *(warm is insufficient)* [1]

step 4 is conditional of structure E

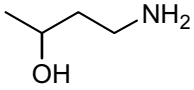
step 4: warm + in H_2O [1]

[5 max 4]

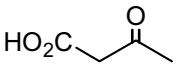
(c) (i)



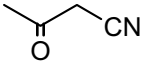
F



G



H



J

F must be an **amide**

[4]

(ii) reaction 1: H_2 + Ni *or* $LiAlH_4$ [1]
reaction 2: heat + aqueous HCl [1]
[6]

[Total: 14]

6 (a) (i) Condensation [1]

(ii) ala-ala, gly-gly, ala-gly [2]
[3]

(b) (i) Correct sugar-phosphate backbones
(with **two sugars and one phosphate attached**) [1]

C – G pair correct ***or*** A – T pair correct [1]

deoxyribose label **and** all bases coming from sugars [1]

(ii) Replication would be slower/difficult
because the DNA/strands could not be separated [1]
[4]

(c) (i) Some amino acids have more than one (triplet) code [1]

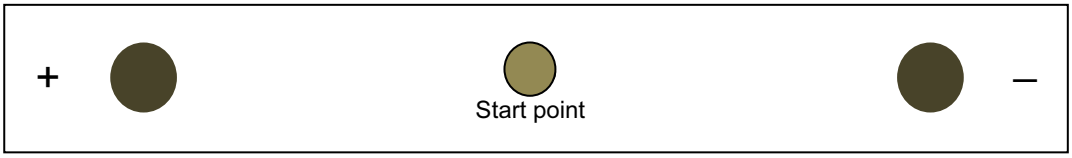
(ii) loss/disruption of ionic bonding/hydrogen bonding [1]

(iii) There would be a potential loss of all tertiary structure
or
frameshift – deletion of a base changes protein structure [1]

[3]

[Total: 10]

7 (a)



Glutamic acid Glycine Lysine

Glutamic acid between + and start point [1]
Lysine between – and start point [1]
Glycine at, or *very* close to, start point [1]
[3]

(b) (i) Ratio of the concentration of a solute in each of two solvents
or equilibrium constant representing the distribution of a solute between two solvents. [1]

(ii) illustration of some method of getting into our body via the food chain [1]

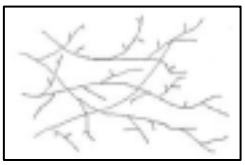
They dissolve preferentially in fats/oils [1]
[3]

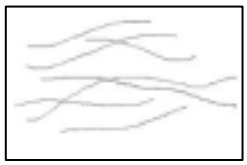
(c) (i) $156 = C_3H_6{}^{35}Cl^{79}Br^+$ [1]
$158 = C_3H_6{}^{37}Cl^{79}Br^+$ [1]
$158 = C_3H_6{}^{35}Cl^{81}Br^+$ [1]
$160 = C_3H_6{}^{37}Cl^{81}Br^+$ [1]

(ii) *m/e* = 15 Species = CH_3^+ [1]
[5 max 4]

[Total: 10]

8 (a)





LDPE HDPE minimum of 2 chains suitable sketches [1]

(The close packing of unbranched side chains means)
LDPE **more space** between the chains/polymers or HDPE less empty space between the chains [1]
[2]

(b) van der Waals' (VDW) forces [1]
are weaker [1]
[2]

(c)

Addition OR	**condensation**
requires C=C/double bond	does not need C=C/double bond
uses the same functional group	needs two different functional groups
same general (empirical) formula as monomer	different formula
no loss of small molecule/H_2O/HCl	small molecule /H_2O/HCl is formed

Any two differences [1]
[2]

(d) (i) (through its long chain of) delocalised electrons/mobile electrons [1]
free electrons is not sufficient

(ii) planar [1]

the π bonds/p-orbitals overlap (with each other) [1]

(iii) C_8H_6
C_4H_3 [2]

[5 max 4]

[Total: 10]