2010 National Qualifying Exam – Chemistry
Solutions

Section A (Multiple Choice)

Question #	Answer	Question #	Answer	Question #	Answer
Q1	D	Q6	D	Q11	C
Q2	D	Q7	A	Q12	B
Q3	A	Q8	E	Q13	E
Q4	B	Q9	E	Q14	B
Q5	B	Q10	A	Q15	A

Question 16

a. What is the oxidation state of chromium in the following species?

i)	Cr_2O_3	III
ii)	CrO_4^{2-}	VI
iii)	$Cr_2O_7^{2-}$	VI
iv)	$FeCr_2O_4$	III

b. Write the full balanced equations for the reduction of chromite using carbon and ferrosilicon.

$FeCr_2O_4 + 2C \rightarrow Fe + 2Cr + 2CO_2$

c.

i) Write the half equation for the oxidation of chromite in base.

$8OH^- + Cr_2O_4^{2-} \rightarrow 2CrO_4^{2-} + 4H_2O + 6e^-$

ii) Write the reduction half-equation.

$4e^- + 2H_2O + O_2 \rightarrow 4OH^-$

iii) Write the balanced full-equation.

$4OH^- + 2Cr_2O_4^{3+} + 3O_2 \rightarrow 4CrO_4^{2-} + 2H_2O$

d. Write the half-equations and the full balanced equation for the reaction of chromate with iodide.

$8H^+ + CrO_4^{2-} + 3e^- \rightarrow Cr^{3+} + 4H_2O$ **OR** $4H_2O + CrO_4^{2-} + 3e^- \rightarrow Cr^{3+} + 8OH^-$

$3I^- \rightarrow I_3^- + 2e^-$

$16H^+ + 2CrO_4^{2-} + 9I^- \rightarrow 2Cr^{3+} + 8H_2O + 3I_3^-$ **OR** $8H_2O + 2CrO_4^{2-} + 9I^- \rightarrow 2Cr^{3+} + 16OH^- + 3I_3^-$

e. How many triiodide ions are generated for each chromate ion that is reduced?

1.5

f. Write two balanced ionic half equations and a full redox equation for the reaction between triiodide ions and thiosulfate ions.

$2e^- + I_3^- \rightarrow 3I^-$
$2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2e^-$

$I_3^- + 2S_2O_3^{2-} \rightarrow 3I^- + S_4O_6^{2-}$

g. What was the concentration of the stock sodium chromate solution?

$n(S_2O_3^{2-}) = 23.10 \times 10^{-3} \times 0.100$
$= 2.31 \times 10^{-3}$ mol
$n(I_3^-) = 2.31 \times 10^{-3} \times 1/2$
$= 1.155 \times 10^{-3}$ mol
$n(Cr) = 1.155 \times 10^{-3} \times 2/3$
$= 0.77 \times 10^{-3}$ mol
$[Cr]_{STOCK} = 0.77 \times 10^{-3} / 25.00 \times 10^{-3}$
$= 0.0308$ M

h.

i) What percentage of the ore is actually chromite?

$n(FeCr_2O_4) = ½ \times 0.0308$
$= 0.0154$ mol
$m(FeCr_2O_4) = 0.0154 \times (55.85 + 2 \times 52.00 + 4 \times 16.00)$
$= 3.447$ g
$\%(FeCr_2O_4) = 3.447 / 5$
$= 68.9$ %

ii) What percentage of the ore is chromium?
(Assume chromite is the only source of chromium in the ore.)

$m(Cr) = 0.0308 \times 52.00$
$= 1.60$ g
% (Cr) = 1.60 / 5
= 32.0 %

Question 17

(a) 2 x 1.008 + 16.00 = 18.0 (to 1 decimal place)

(b) 89.1 + 105.1 ï 18.0 = 176.2

(c) Ser-Ala or Gly-Thr or Thr-Gly + appropriate structure

(d) 89.1 + 105.1 + 89.1 ï 2 * 18.0 = 247.3

(e) 89.1 + 75.1 + 165.2 + 133.1 ï 3 * 18.0 = 408.5

(f) b1 = 89.1 ï 17.0 = 72.1
b2 = 72.1 + 105.1 ï 18.0 = 159.2

(g) b1 + 17.0 = 89.1 → AA1 = Ala
b2 ï b1 + 18.0 = 121.1 → AA2 = Cys
b3 ï b2 + 18.0 = 75.1 → AA3 = Gly
So AA1 = Ala, AA2 = Cys, AA3 = Gly

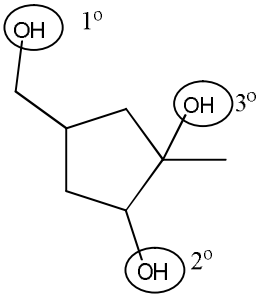
(h) y1 = 89.1 + 1 = 90.1
y2 = 90.1 + 105.1 ï 18 = 177.2

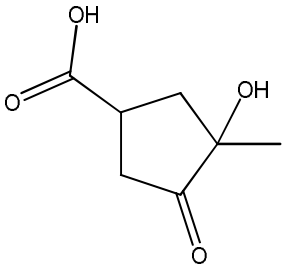
(i) y1 ï 1 = 181.2 → AA3 = Tyr
y2 ï y1 + 18.0 = 115.1 → AA2 = Pro
y3 ï y2 + 18.0 = 131.2 → AA1 = Met
So AA1 = Met, AA2 = Pro, AA3 = Tyr

(j) b1 + 17.0 = 149.2 →AA1 = Met
b2 ï b1 + 18.0 = 165.2 → AA2 = Phe
b5 ï b4 + 18.0 = 155.2 → AA5 = His
y1 ï 1 = 131.2 → AA6 = Ile or Leu
y2 = y1 + 155.2 ï 18.0 = 269.4
y3 ï y2 + 18.0 = 115.1 → AA4 = Pro
b3 = b4 ï 115.1 + 18.0 = 380.5
b3 ï b2 + 18.0 = 119.1 → AA3 = Thr
So AA1 = Met, AA2 = Phe, AA3 = Thr, AA4 = Pro, AA5 = His, AA6 = Ile or Leu

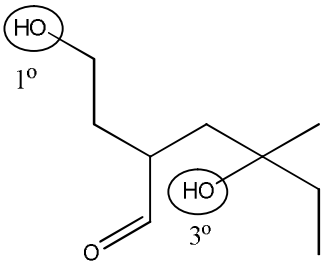
Question 18

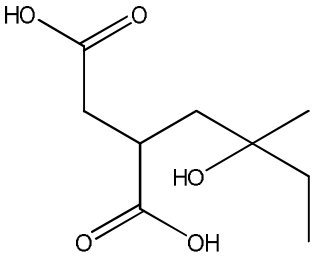
a) i) 3 Marks



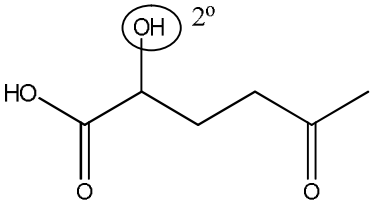


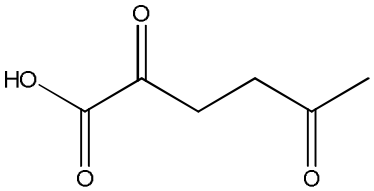
ii) 2 Marks



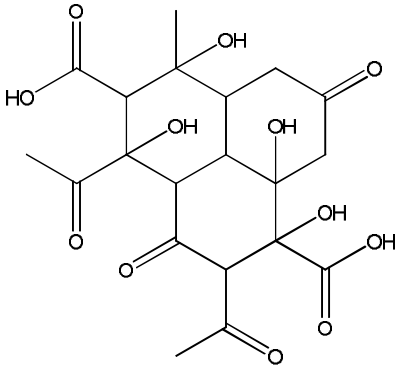


iii) 1 Mark

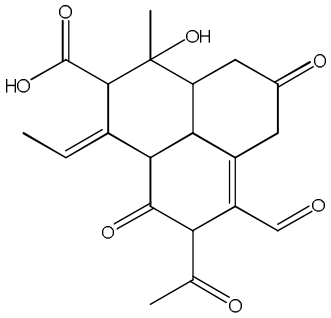




b) 4.5 Marks



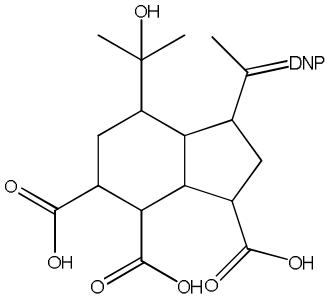
c) 1.5 Marks



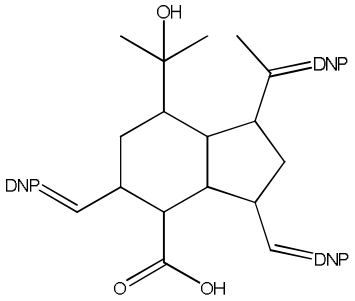
d) 1 Marks

The Iodine was oxidising the alcohols to ketones/aldehydes, but since there was no methyl alcohol or methyl ketones in the structure, iodoform could not form.

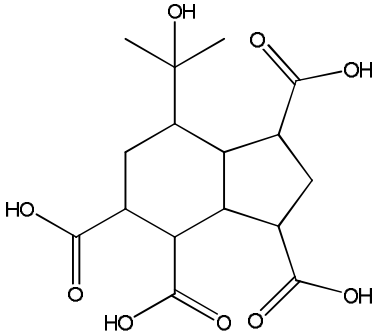
e) i) 2 Marks



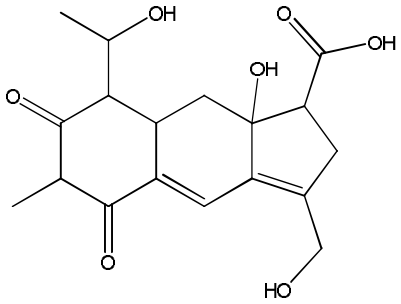
ii) 3 Marks



iii) 2 Marks



f) 3 Marks



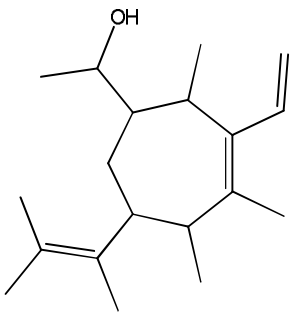
Note: Not the only correct structure, other solutions are possible

g) 4 Marks

- Positive test for TollensôReagent means presence of aldehyde functional group, hence not structure 1
- Positive test for PCC means presence of primary or secondary alcohol, hence not structures 3 or 4
- Positive test for DNP means presence of aldehyde or ketone functional group, hence not structure 1
- Decolourisation in the Iodoform test means the presence of alcohol or aldehyde functional group, but no methyl alcohol or methyl ketone, hence not structures 1, 3 or 5
- Negative test of Blue litmus means that the structure does not include a carboxylic acid functional group, hence not 3
- Acidified $KMnO_4$ reacts with all structures
- Compound E = 2

h) 4 Marks

- DNP must be before PCC or any ketone/aldehyde formed by due to PCC will all react with DNP
- PCC must be before $KMnO_4$ and I_2/NaOH or no reaction would be observed
- The order of $KMnO_4$ and I_2/NaOH does not matter.



Note: Not the only correct structure, other solutions are possible

Reagent 1 = DNP Reagent 2 = PCC Reagent 3 = I_2/NaOH Reagent 4 = $KMnO_4$

OR

Reagent 1 = DNP Reagent 2 = PCC Reagent 3 = $KMnO_4$ Reagent 4 = I_2/NaOH