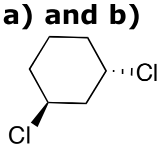
# 2008 National Qualifying Exam – Chemistry
Solutions

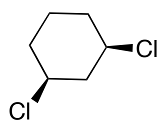
## Section A (Multiple Choice)

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

## Question 16

**a) and b)**

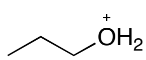

trans

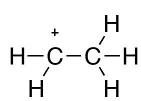

cis

**c)**

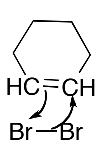
**(i)** O = nucleophilic
**(ii)** N = nucleophilic
**(iii)** C = neither
**(iv)** C = electrophilic, I = nucleophilic

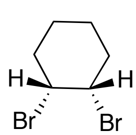
**d)** **(i)** $Br^+$ $Br^-$

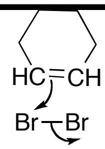
**(ii)**  $NH_3$

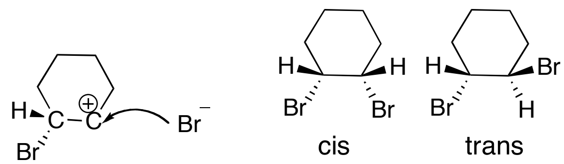
**(iii)** 

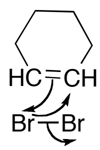
**e)** **(i)** bottom
**(ii)** bottom
**(iii)** both equal

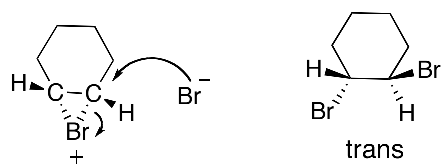
**f)** **(i)** 

**(ii)** 
cis

**g)** **(i)** 

**(ii)** 

**h)** **(i)** 

**(ii)** 

**i)** mechanism 3

## Question 17

Chemistry NQE 2008 Q17

**a)**
i) Manganese, +VII, $MnO_4^-$
ii) Carbon, -III, **C**$H_3COOH$,

**b)**
$C_2H_6O + H_2O \rightarrow C_2H_4O_2 + 4\ H^+ + 4\ e^-$ [oxidation]
$MnO_4^- + 8\ H^+ + 5\ e^- \rightarrow Mn^{2+} + 4\ H_2O$

**c)**
$5\ C_2H_6O + 4\ MnO_4^- + 12\ H^+ \rightarrow 5\ C_2H_4O_2 + 4\ Mn^{2+} + 11\ H_2O$

**d)**
$n(MnO_4^-) = 0.05 \times 0.0144 = 7.20 \times 10^{-4}$ M
$n(CH_3CH_2OH) = 5/4 \times 7.20 \times 10^{-4} = 9.00 \times 10^{-4}$ M
$[CH_3CH_2OH]$ in diluted white wine $= 9.00 \times 10^{-4}$ M$/0.02 = 4.50 \times 10^{-2}$ M

**e)**
$[CH_3CH_2OH]$ in white wine = 4.50 x $10^{-2}$ M x 500/10 = 2.25 M
1 L of wine has 2.25 x $M_w$ ($CH_3CH_2OH$) = 2.25 x 46.07 = 103.7 g
v($CH_3CH_2OH$) = 103.7/.79 = 131.2 mL
% v/v = 13.1 %

**f)**
If 1.2g of acetic acid in 1L $[CH_3COOH]$ = 1.2/60.05 = 1.998 x $10^{-2}$ M
20.00 mL diluted to 100.00 mL $[CH_3COOH]$ = 3.997 x $10^{-3}$ M
n($CH_3COOH$) in 10.00 mL = 3.997 x $10^{-5}$ M
If approx. 20.00 mL titre of NaOH, [NaOH] = 3.997 x $10^{-5}$/0.02 = 1.998 x $10^{-3}$ M
Most appropriate solution is 2.00 x $10^{-3}$ M

**g)**
All ethanol in wine now converted to acetic acid
$[CH_3COOH]$ in distillate = (2.25+1.998 x $10^{-2}$)/5 = 0.45299 M
A higher concentration of acetic acid requires a higher concentration of NaOH.
Use strongest NaOH available.

**h)**
No, even if the interference of the additional acetic acid produced from the reaction with $MnO_4^-$ was taken into account, the proportion of the original acetic acid is very small and with this method its determination would be inaccurate.

## Question 18

**(a)** From Figure 2, $\varepsilon_{Try}$ = 5.6 × $10^3$ $M^{-1}$ $cm^{-1}$ and $\varepsilon_{Tyr}$ = 1.4 × $10^3$ $M^{-1}$ $cm^{-1}$

**(b)** $\varepsilon_{glucagon}$ = (2 × 1.4 × $10^3$ + 1 × 5.6 × $10^3$) = **8.4 × $10^3$ $M^{-1}$ $cm^{-1}$**

**(c)** $c = \frac{A}{\varepsilon \times \ell} = \frac{0.95}{8.4 \times 10^3 \times 1}$ = 1.13 × $10^4$ mol $L^{-1}$ (**1.1 × $10^4$ mol $L^{-1}$** to 2 SF)

**(d)** 1.13 × $10^4$ mol $L^{-1}$ × 3485 g $mol^{-1}$ = **0.39 g $L^{-1}$**

**(e)**

**(i)** 1.0 g $L^{-1}$ glucagon = $\frac{1.0}{3485}$ = 2.87 × $10^{-4}$ mol $L^{-1}$

A = ε × c × ℓ = 8.4 × $10^3$ $M^{-1}$ $cm^{-1}$ × 2.87 × $10^{-4}$ M × 1.0 cm = 2.41 (**2.4** to 2 SF)

**(ii)**

Amino acid frequency in glucagon is: $\frac{2}{29} \times 100$ = 6.90% tyrosine and $\frac{1}{29} \times 100$ = 3.45% tryptophan.

ε(100 amino acids in glucagon) = (6.90 × 1.4 × $10^3$ + 3.45 × 5.6 × $10^3$) = 2.9 × $10^4$ $M^{-1}$ $cm^{-1}$

ε(100 amino acids in **average** polypeptide) = (3.4 × 1.4 × $10^3$ + 1.3 × 5.6 × $10^3$) = 1.2 × $10^4$ $M^{-1}$ $cm^{-1}$

A(1.0 g $L^{-1}$ **average** polypeptide) =
A(1.0 g $L^{-1}$ glucagon) × $\frac{\varepsilon(\text{100 amino acids in average polypeptide})}{\varepsilon(\text{100 amino acids in glucagon})}$ =

2.41 × $\frac{1.24 \times 10^4}{2.90 \times 10^4}$ = **1.0**

(f) ε(unknown protein) = (3 × 1.4 × $10^3$ + 6 × 5.6 × $10^3$) = 3.78 × $10^4$ $M^{-1}$ $cm^{-1}$

A(0.24 g $L^{-1}$ glucagon) = 0.24 × 2.41 = 0.578

A(unknown protein) = 1.85 – 0.578 = 1.27

c(unknown protein) = $\frac{1.27}{3.78 \times 10^4 \times 1}$ = **3.4 × $10^{-5}$ mol $L^{-1}$**

## Question 19

**a)** *(1 mark)*

Non-metal

**b)** *(2 marks)*

n(NaOH) = cV
= 1.00 M × 0.018L
= 0.018mol

$M_w$ = $^{m}/_{n}$
= $^{0.29}/_{0.018}$
= 16.1 (× 2 = 32.2 → S)
= Sulfur

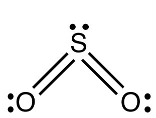
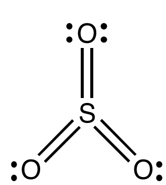
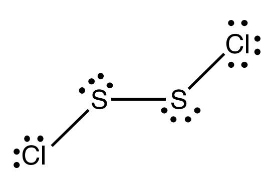
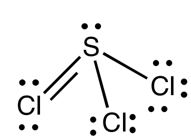
**c)**

| | | |
|---|---|---|
| **A** *(2 marks)* | S <u>or</u> $S_8$ | |
| **B** *(2 marks)* | $SO_2$ | $S + O_2 \rightarrow SO_2$ |
| **C** *(2 marks)* | $SO_3$ | $2 - SO_2 \rightarrow 2SO_2$ |
| **D** *(2 marks)* | $H_2SO_3$ | $SO_2 + H_2O \rightarrow H_2SO_3$ |
| **E** *(2 marks)* | $H_2SO_4$ | $SO_3 + H_2O \rightarrow H_2SO_4$ |
| **F** *(3 marks)* | $S_2Cl_2$ | $2S + Cl_2 \rightarrow S_2Cl_2$<br>$S_2Cl_2 + Cl_2 \rightarrow 2SCl_2$ |

**d)**

| |
|---|
| **H** *(3 marks)*<br>$SCl_2 + SO_3 \rightarrow SOCl_2 + SO_2$<br>H |
| **I** *(3 marks)*<br>$SOCl_2 + 2H_2O \rightarrow H_2SO_3 + 2HCl$ |

**e)** *(2 marks each)*

| B | C | F | F |
|---|---|---|---|
|  |  |  |  |
| Bent | Trigonal planar | Open book shaped | Pyramidal |