**Any alternative method of solution to any question that is scientifically and mathematically correct and leads to the same answer will be accepted with full credit. Partially correct answers will gain partial credit.**

**For questions requiring calculations, full credit is given only when the necessary steps of the calculations are written. In problems having related sub-parts, consistency of answers of the related sub-parts is also checked during evaluation.**

## Problem 1 — 23 marks

## The golden alloy

**1.1**

| | Yes | No |
|---|---|---|
| Cu & Ag | X | |
| Cr & K | | X |
| Cu & Al | | X |
| Ag & Al | | X |

**1.2** 300 ºC – γ + ε phase  750 ºC – γ + liquid phase

**1.3 i)** $2\ Cu^{2+}(aq) + 4\ I^{-}(aq) \rightarrow Cu_2I_2(s) + I_2\ (aq)$

**ii)** $I_2\ (aq) + 2Na_2S_2O_3\ (aq) \rightarrow Na_2S_4O_6\ (aq) + 2\ NaI\ (aq)$

**iii)** Cu (I) has $3d^{10}$ configuration.
Magnetic Moment = 0 BM

**iv)** a) [X]

**v)** mmole of Cu (II) in the sample = 0.72 mmol
mmole of Zn (II) in the sample = 0.277 mmol
% Zn in the sample = 28.35%

**vi)** α-brass

**vii)** a) [X]  b) [X]

**1.4 i)** Molar mass of cupron, $C_{14}NO_2H_{13}$ = 227 g $mol^{-1}$
$y$ = 2

**ii)** $2ZnNH_4PO_4\,(s) \rightarrow Zn_2P_2O_7\,(s) + 2NH_3\,(g) + H_2O\,(g)$

**iii)** Molar mass of zinc pyrophosphate = 366 g $mol^{-1}$

Mass of zinc pyrophosphate = 256.2 mg

**1.5** b) X c) X

**1.6**

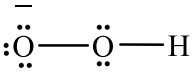
| Reaction | Metal ion(s) and their form in supernatant | Composition of precipitate |
|---|---|---|
| Ni-brass solution + excess NaOH (aq.) | $[Zn(OH)_4]^{2-}$ | $Cu(OH)_2$, $Ni(OH)_2$ |
| Ni-brass solution + excess $NH_3$ (aq.) till pH is 9.5 | $[Cu(NH_3)_4]^{2+}$, $[Ni(NH_3)_6]^{2+}$ | $Zn(OH)_2$ |

**1.7 i)** Site **A** $Cu^{2+}$ Site **B** $Zn^{2+}$ **ii)** $Cu^{2+}$

## Problem 2 — 25 marks

## Hydrogen Peroxide- a Versatile Reagent

**2.1**

**i)** 

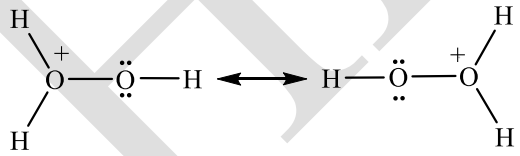
**ii)** $H_2O_2(aq) + OH^-(aq) \rightleftharpoons [HO_2^-](aq) + H_2O\,(l)$

**2.2** Molarity of $H_2O_2$ = 0.888 M

pH = 5.9

**2.3**

**i)** $H_2O_2(aq) + H_2SO_4(aq) \rightleftharpoons [H_3O_2]^+(aq) + HSO_4^-\,(aq)$

**ii)** 

**2.4**

i) $2KI\,(aq) + H_2O_2\,(aq) + H_2SO_4(aq) \rightarrow I_2(aq) + K_2SO_4(aq) + 2H_2O\,(l)$

ii) $2KMnO_4(aq) + 5H_2O_2(aq) + 3H_2SO_4\,(aq) \rightarrow 2MnSO_4(aq) + K_2SO_4(aq) + 8H_2O\,(l) + 5O_2(g)$

or

i) $2I^-(aq) + H_3O_2^+(aq) + H^+(aq) \rightarrow I_2(aq) + 2H_2O\,(l)$

ii) $2MnO_4^-(aq) + 5H_3O_2^+(aq) + H^+(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O\,(l) + 10O_2\,(g)$

**2.5 i)**

$2CoS\,(s) + 3O_2\,(g) \rightarrow 2CoO\,(s) + 2SO_2\,(g)$

$2NiS\,(s) + 3O_2\,(g) \rightarrow 2NiO\,(s) + 2SO_2\,(g)$

**ii)**

Total $SO_2$ produced = 2.215 mol

The volume of gas at 850 ºC = 203.97 L

**2.6 i)**

Total moles of $H_2O_2$ required = 9.097 mol

Mass of water in 30% $H_2O_2$ = 1031.3 – 309.39 = 0.722 kg

Mass of water in the sulfuric acid solution is = 0.850 kg

Mass of water produced = 0. 149 kg

Total mass of water = 1.719 kg

Molality of Mo = 0.471 mol $kg^{-1}$

**ii)** $Na^+$, $Cl^-$, $SO_4^{2-}$, $OH^-$ and DMG

**iii)** $Na_2SO_4$

**iv)**

| | reduces consumption of | enhances yield of | decreases contamination in | increases contamination in |
|---|---|---|---|---|
| I. When added in the chosen step __II___, | DMG | | | |
| II. When added in another step _I___, | | | | Ammonium Molybdate |

**2.7** a) X It prevents formation of $SO_2$ as waste product.

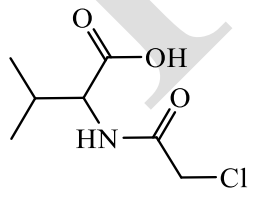
b) X It enhances formation of $Na_2SO_4$ as a useful by-product.

## Problem 3 — 21 Marks

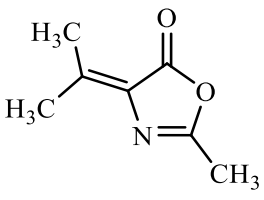
## Structure Elucidation of a Drug

**3.1** c) X

**3.2 i)**



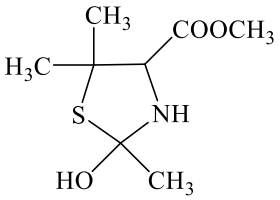
**D**



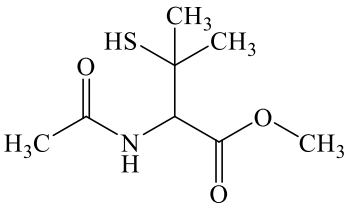
**E**

**ii)** b) X

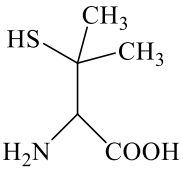
**iii)**



**F**



**G**

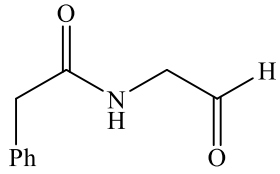


**B**

**iv)** $pk_a$ = 1.8 | – COOH | 7.9 | – SH | 10.5 | – $NH_2$

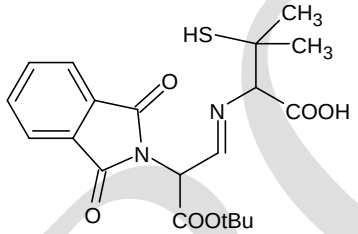
**v)** Team 1 Statement(s) b and c

**3.3**

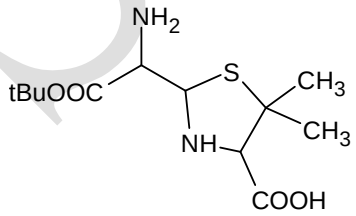


**C**

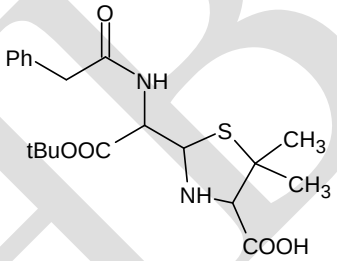
**3.4 i)**



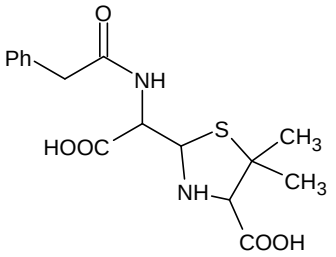
**H**



**I**

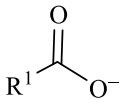


**K**

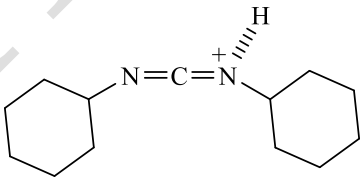


**L**

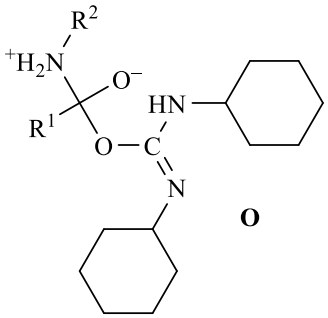
**ii)**



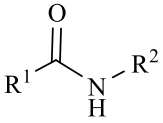
**M**



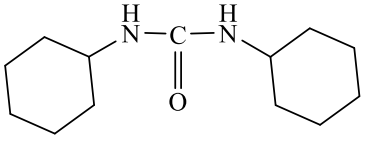
**N**



**O**

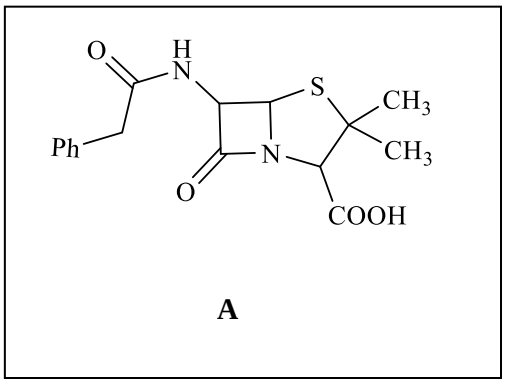


**P**



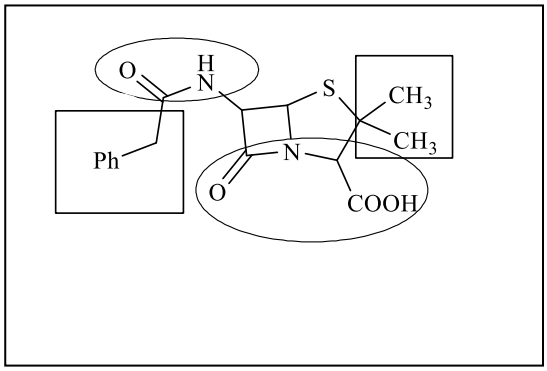
**Q**

iii)



A

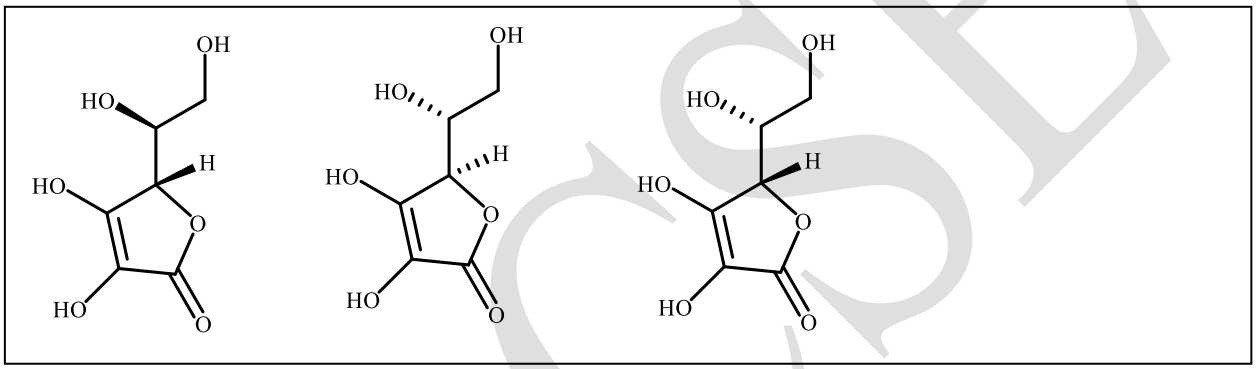
iv)



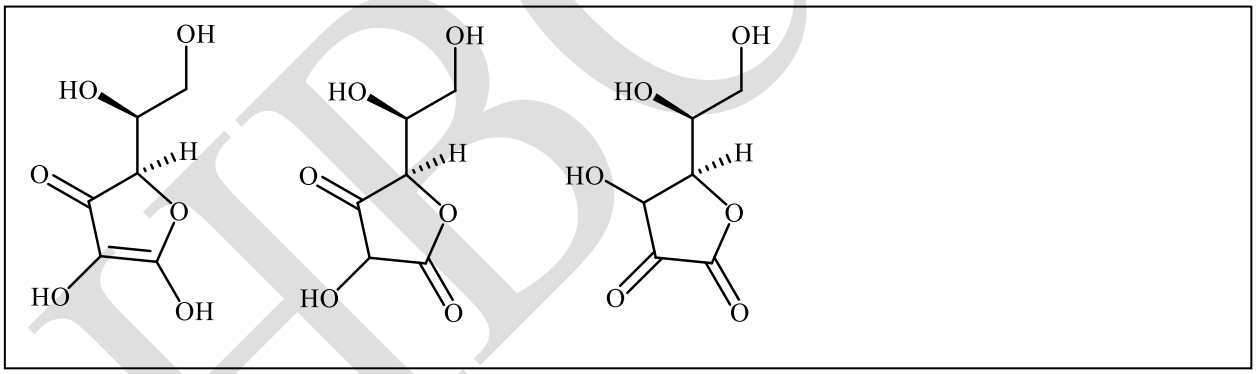
## Problem 4 — 24 Marks

## An acid from sugar

**4.1**



**4.2**

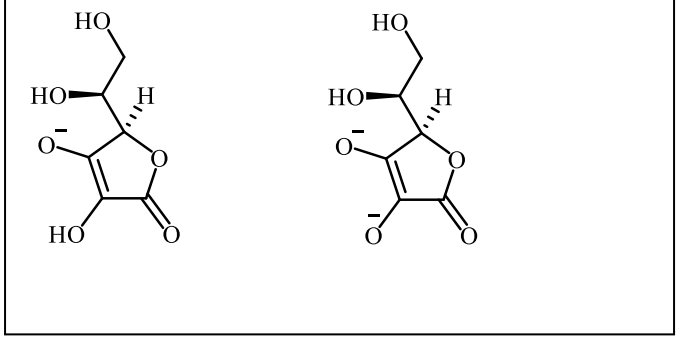


**4.3**

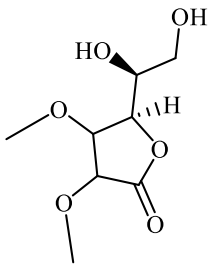
$pKa_1 = 4.2$

**4.4**

**pH 7.3** **pH 12.0**



**4.5**

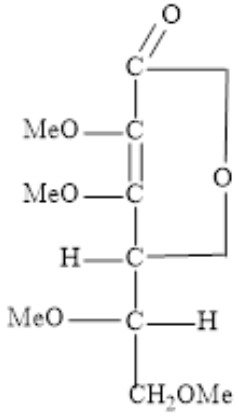


**B**

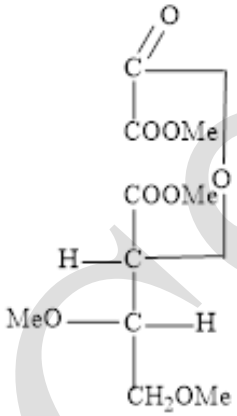
$NaIO_4$ / $Pb(OAc)_4$

**X**

**4.6** Molecular Formula – $C_{10}H_{16}O_7$



**C**

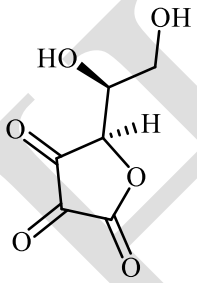


**D**

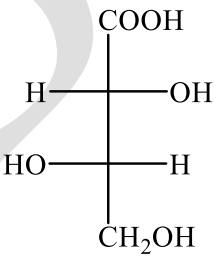
**4.7** a) X

**4.8** d) X

**4.9**



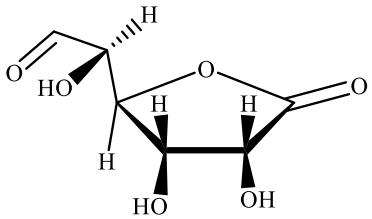
**E**



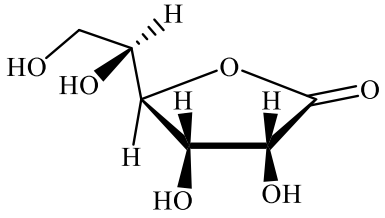
**F**

**4.10** a) X

**4.11**

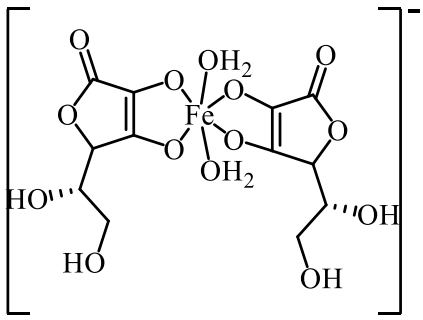


**H**

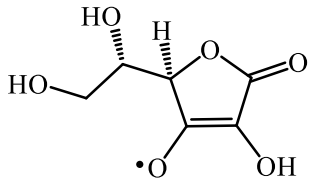


**I**

**4.12**



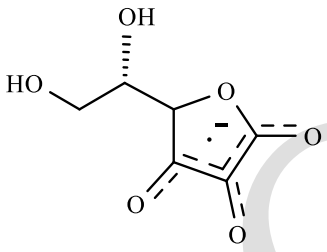
**4.13**



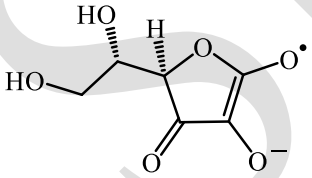
**J**

$OH^-$

**K**

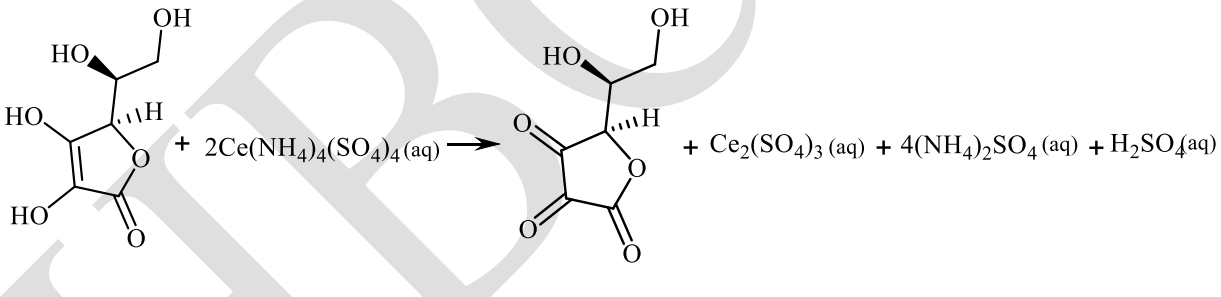


**or**



**L**

**4.14**




**A** **E**

**Problem 5** **16 marks**

## The purple hydrogen

**5.1**

Lowest energy wavelength = 656.3 nm

Frequency of this line is = $4.57 \times 10^{14}$ Hz

**5.2 i)**

The wavelength 121.6 nm should correspond to n = 2 to n = 1 transition

Energy of photon for this transition is = $h\nu/(121.6\ nm) = -C/2^2 + C/1^2$

$C = 109{,}769\ cm^{-1} = 2.18 \times 10^{-18}$ J

**ii)**

102.6 nm, n = 3 → 1

434.0 nm, n = 5 → 2

**5.3**

$v = 0.2185 \times 10^7$ m/s

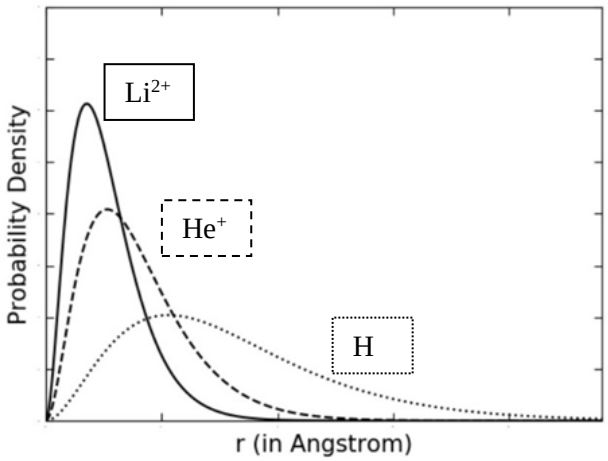
Ratio of velocity of electron in hydrogen atom to speed of light = 1:137

**5.4**

$\frac{df(r)}{dr} = 0, r = a_0$

**5.5** d) X

**5.6**




**5.7**

When intensity drops to 10% of the initial intensity, $0.1 = e^{-kt}$

$t = 2.303 \times 10^{-8}$ s

**5.8**

No color