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

(2 marks)

1.2 300 ºC – γ + ε phase 750 ºC – γ + liquid phase **(1 mark)**

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

Or

$2\ Cu^{2+}(aq) + 5I^-(aq) \rightarrow Cu_2I_2(s) + I_3^-\ (aq)$ **(1 mark)**

ii) $I_2\,(aq) + 2Na_2S_2O_3\,(aq) \rightarrow Na_2S_4O_6\,(aq) + 2\ NaI\,(aq)$ **(1 mark)**

iii) Cu (I) has $3d^{10}$ configuration.

Magnetic Moment = 0 BM **(1 mark)**

iv) a) [X] **(0.5 mark)**

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% **(2.5 marks)**

vi) α-brass **(0.5 mark)**

vii) a) [X] b) [X] **(1 mark)**

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

ii) $2ZnNH_4PO_4\,(s) \rightarrow Zn_2P_2O_7\,(s) + 2NH_3\,(g) + H_2O\,(g)$ **(1.5 marks)**

iii) Molar mass of zinc pyrophosphate = 304 g mol^{-1}
Mass of zinc pyrophosphate = 212.8 mg **(2 marks)**

1.5 b) X c) X **(1 mark)**

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	$[Cu(NH_3)_4]^{2+}$, $[Ni(NH_3)_6]^{2+}$ #	$Zn(OH)_2$

(4 marks)

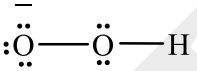
In the supernatant, $[Zn(NH_3)_4]^{2+}$ can also form in addition to $Zn(OH)_2$ precipitate.

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

Problem 2 — 25 marks

Hydrogen Peroxide- a Versatile Reagent

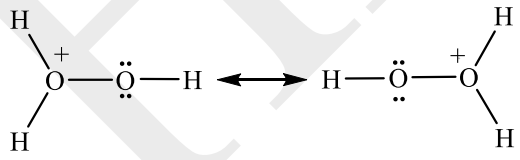
2.1

i) 

ii) $H_2O_2(aq) + OH^-(aq) \rightleftharpoons [HO_2^-](aq) + H_2O\,(l)$ **(1.5 marks)**

2.2 Molarity of H_2O_2 = 0.888 M
pH = 5.9 **(2.5 marks)**

2.3 **i)** $H_2O_2(aq) + H_2SO_4(aq) \rightleftharpoons [H_3O_2]^+(aq) + HSO_4^-\,(aq)$ **(1 mark)**

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

(2.5 marks)

2.5 i) (1 mark)

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

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

ii) (3 marks)

Total SO_2 produced = 2.215 mol

The volume of gas at 850 ºC = 203.97 L

2.6 i) (6 marks)

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) (2.5 marks)

Na^+, Cl^-, SO_4^{2-}, OH^-, NH_4^+ and DMG

iii) (1 mark)

Na_2SO_4

iv)

	reduces consumption of	enhances yield of	decreases contamination in	increases contamination in
I. When added in the chosen step __2___, When added in the chosen step __3__,	DMG NaOH	 $Ca(OH)_2$		
II. When added in another step _1___,				Ammonium Molybdate

(2 marks)

2.7 a) X It prevents formation of SO_2 as waste product. (2 marks)

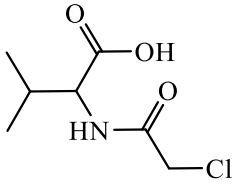
b) X It enhances formation of Na_2SO_4 as a useful by-product.

Problem 3 — 21 Marks

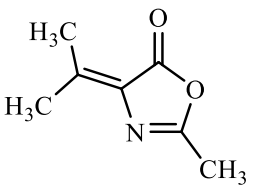
Structure Elucidation of a Drug

3.1 c) X **(1 mark)**

3.2 i) (2.5 marks)



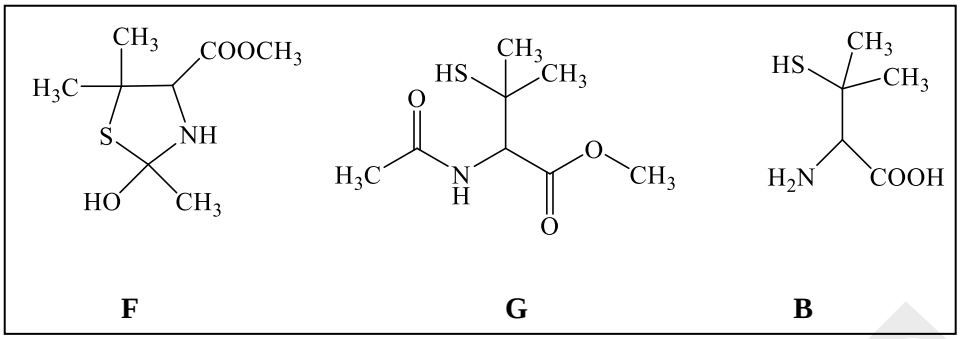
D



E

ii) b) X **(1 mark)**

iii) **(3 marks)**

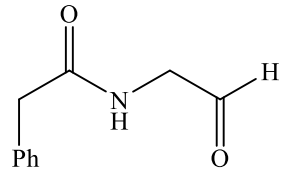


F **G** **B**

iv) pk_a = 1.8 – COOH 7.9 – SH 10.5 – NH_2 **(1.5 marks)**

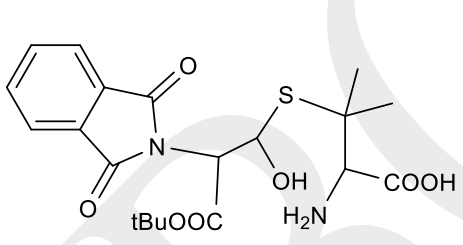
v) Team 1 Statement(s) b and c **(1 mark)**

3.3 **(1 mark)**

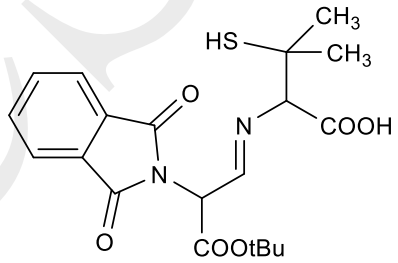


C

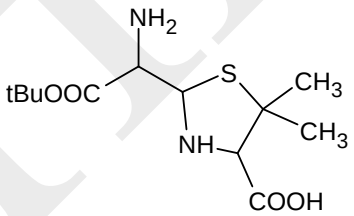
3.4 i)



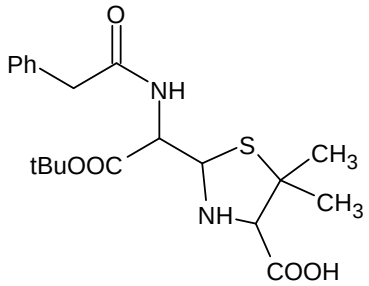
OR



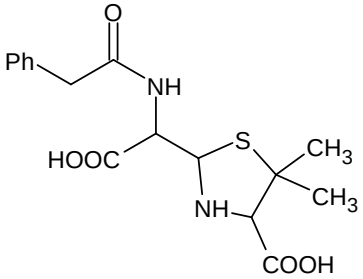
H



I



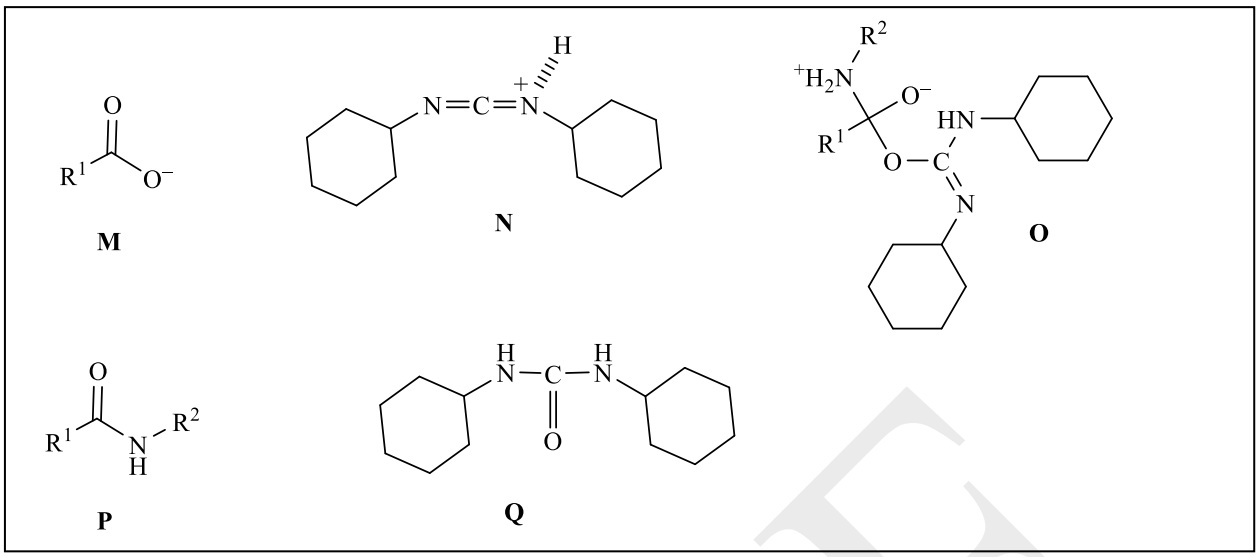
K



L

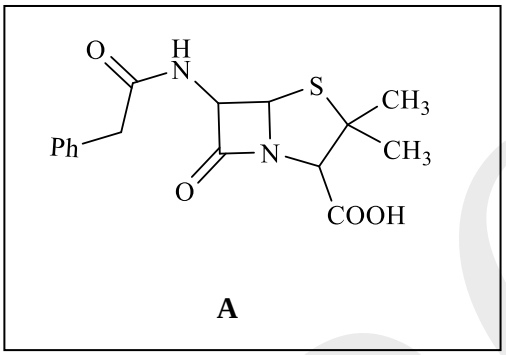
(4 marks)

ii)



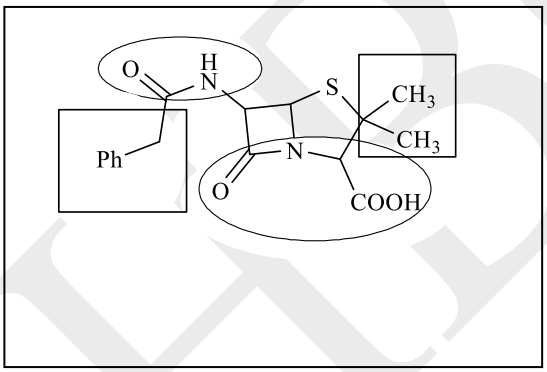
(3 marks)

iii)



(1 mark)

iv)

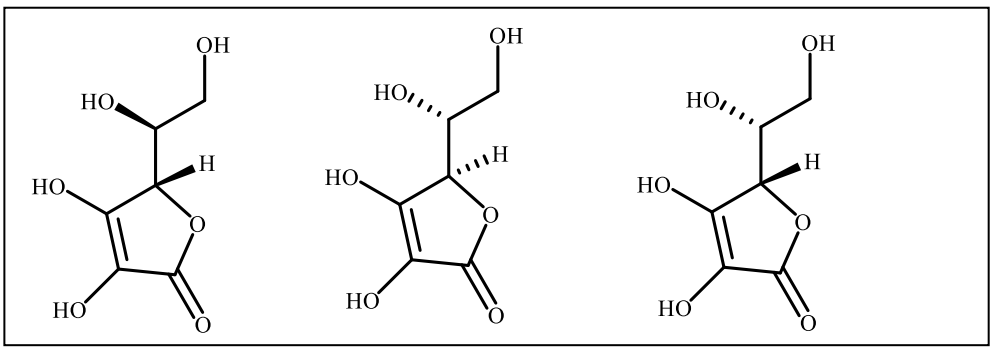


(2 marks)

Problem 4 — 24 Marks

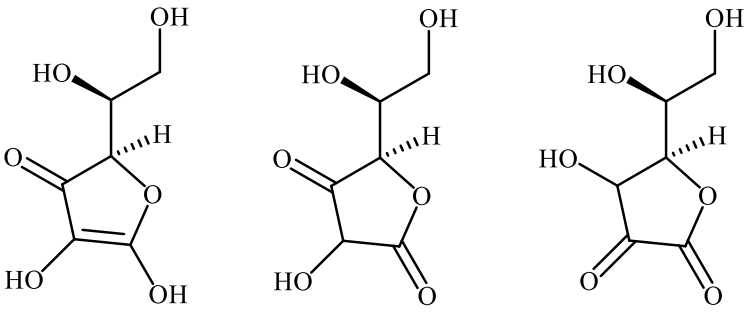
An acid from sugar

4.1



(1.5 marks)

4.2 **(1.5 marks)**

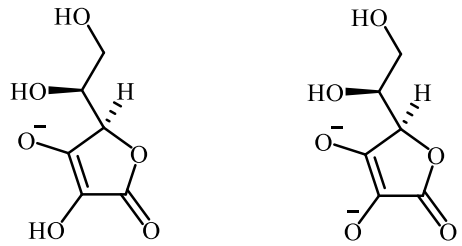


4.3 **(2 marks)**

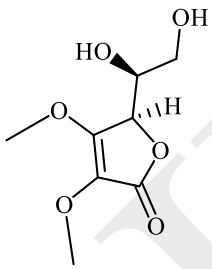
$pKa_1 = 4.2$

4.4 **(2 marks)**

pH 7.3 **pH 12.0**



4.5 **(2 marks)**



$NaIO_4$ / $Pb(OAc)_4$/ HIO_4

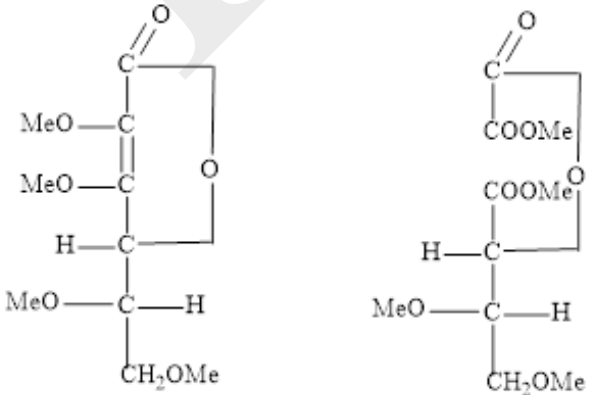
B **X**

($C_8H_{12}O_6$)

As incorrect molecular formula of **B** was provided in the question, 1 mark for **B** is given to all students uniformly.

4.6 **(4 marks)**

Molecular Formula – $C_{10}H_{16}O_8$



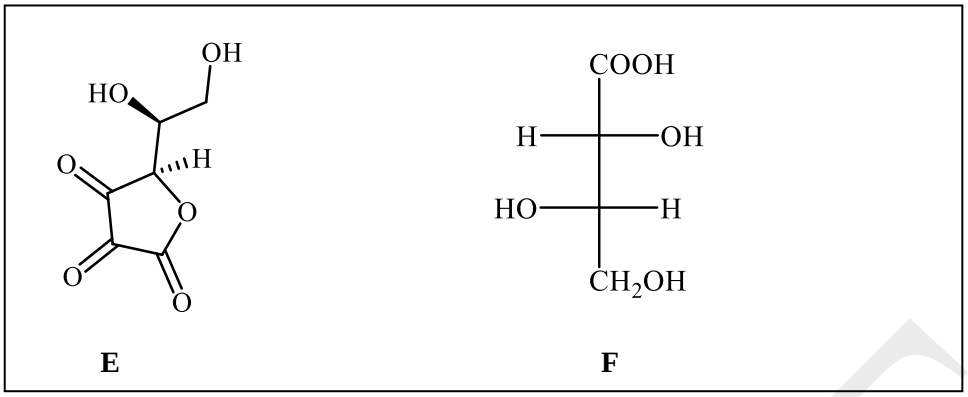
C **D**

Since there was error in percentage of carbon and hydrogen in **D** given in question, 2 marks (for structures **C** and **D**) are given to all students uniformly.

Derivation of molecular formula of **D** ($C_{10}H_{16}O_7$) consistent with data given in question paper will be given 2 marks as per the solution written by student.

4.7 a) [X] **(1 mark)** **4.8** d) [X] **(0.5 mark)**

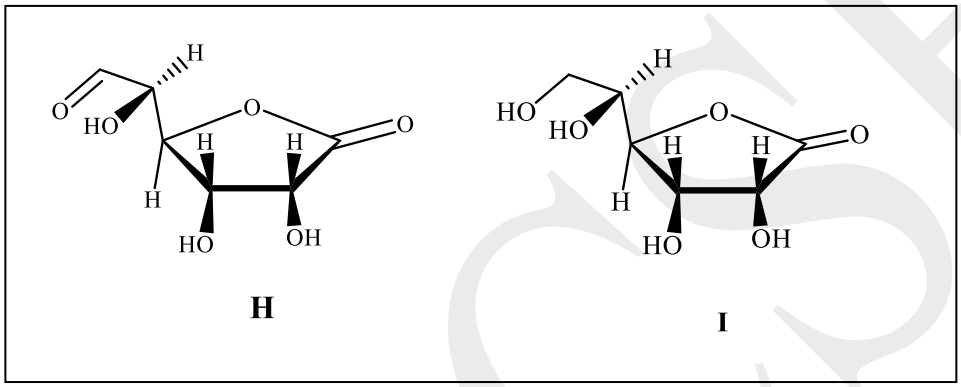
4.9 **(2 marks)**



E **F**

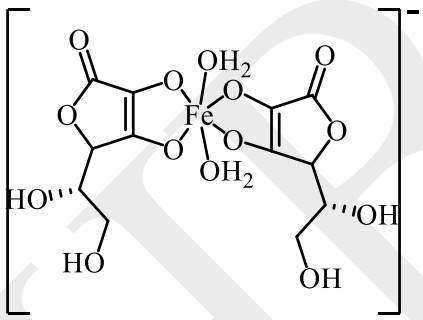
4.10 a) [X] **(1 mark)**

4.11 **(1.5 marks)**

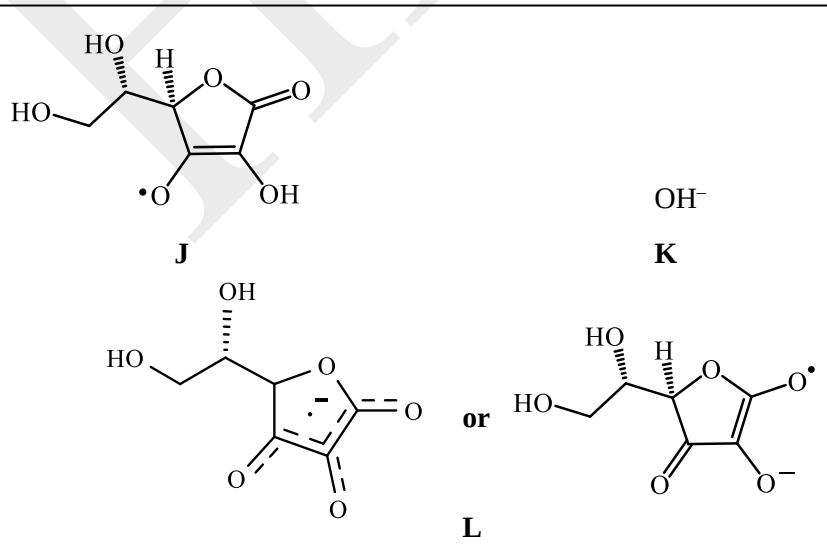


H **I**

4.12 **(1 mark)**



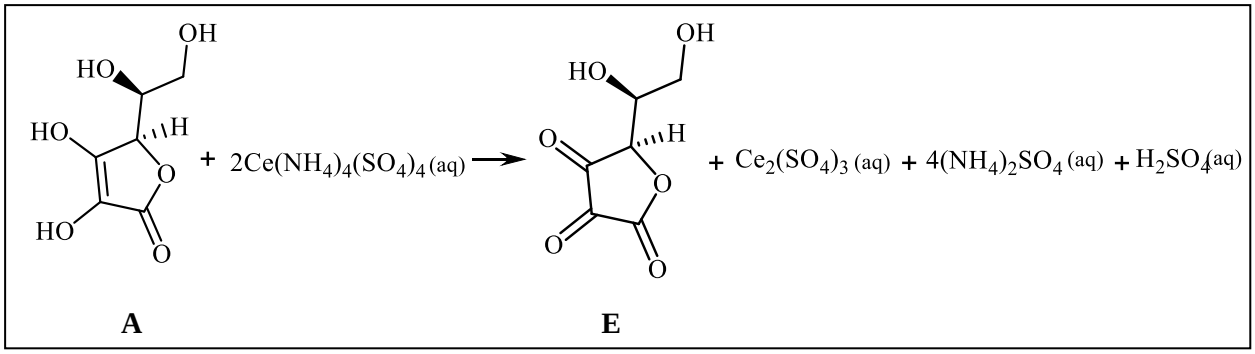
4.13 **(2 marks)**



J **K**

L

4.14



A **E**

(2 marks)

Problem 5 — 16 marks

The purple hydrogen

5.1 Frequency of lowest energy line is = 4.57×10^{14} Hz **(1.5 marks)**

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

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

$C = 109{,}769\text{ cm}^{-1} = 2.18 \times 10^{-18}$ J **(4 marks)**

ii) 102.6 nm, n = 3 → 1

434.0 nm, n = 5 → 2 **(2 marks)**

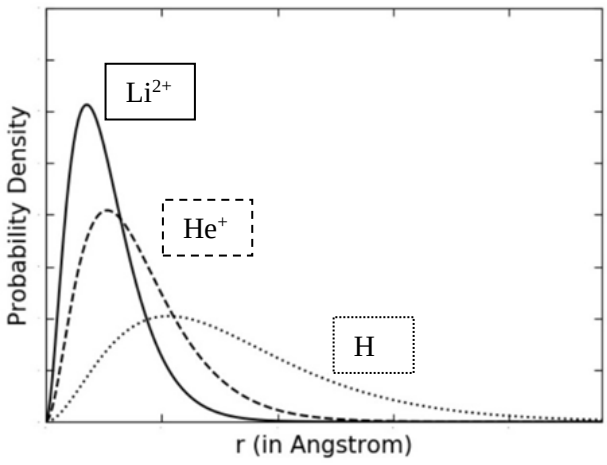
5.3 $v = 2.185 \times 10^6$ m/s

Ratio of velocity of electron in hydrogen atom to speed of light = 1:137 **(2 marks)**

5.4 $\frac{df(r)}{dr} = 0, r = a_0$ **(2 marks)**

5.5 d) X **(1.5 marks)**

5.6 **(1 mark)**



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

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

(1.5 marks)

5.8 No color

(0.5 mark)