අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2014 අගෝස්තු

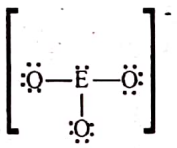
General Certificate of Education (Adv.Level) Examination, August 2014

Chemistry - I/Two hours

- *Periodic Table is Provided.*
- *This paper consists of 08 pages.*
- *Answer all the questions.*
- ***Use of calculators is not allowed.***
- ***Write your Index Number** in the space provided in the answer sheet.*
- *Follow the instructions given on the back of the answer sheet carefully.*
- *In each of the questions 1 to 50, pick one of the alternatives form (1), (2), (3), (4), (5) which is **correct** or **most appropriate** and **mark your response on the answer sheet with a cross (x) in accordance with the instructions given on the back of the answer sheet.***

Universal gas constant	R	= 8.314 J K^{-1} mol^{-1}
Avogadro constant	N_A	= 6.022 x 10^{23} mol^{-1}
Planck's constant	h	= 6.626 x 10^{-34} Js
Velocity of light	c	= 3 x 10^8 ms^{-1}

1. The neutron was discovered by
   (1) Niels Bohr (2) Ernest Rutherford
   (3) James Chadwick (4) Albert Einstein
   (5) Eugen Goldstein.

2. 

   In the structure given above, **E** is an element belonging to the *p*-block of the Periodic Table. To which group does element **E** belong?
   (1) Group 13/III A (2) Group 14/IV A
   (3) Group 15/V A (4) Group 16/VI A
   (5) Group 17/VII A

3. What is the IUPAC name of the following compound?

   $NH_2\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}C(=O)\text{-}CH_2OH$

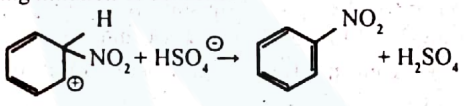
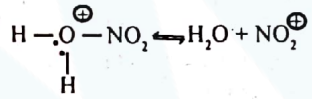
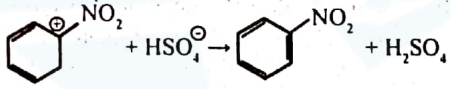
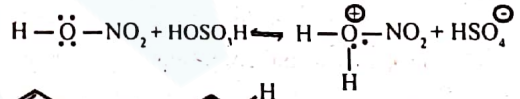
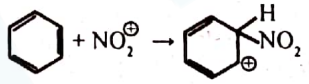
   (1) 1-amino-6-hydroxy-2-hexen-5-one
   (2) 6-amino-1-hydroxy-4-hexen-2-one
   (3) 6-amino-2-oxo-4-hexen-1-ol
   (4) 6-hydroxy-5-oxo-2-hexenamine
   (5) 6-hydroxy-5-oxo-2-hexenylamine

4. The maximum number of electrons having quantum numbers $n = 3$ and $l = 2$ in an atom are
   (1) 2 (2) 4 (3) 6
   (4) 8 (5) 10

5. Of the following, which one has the highest boiling point?
   (1) H_2 (2) He (3) Ne
   (4) Xe (5) CH_4

6. What mass of NaCl (to the nearest gram) would contain the same total number of ions as 285 g of $MgCl_2$? (Na = 23, Mg = 24, Cl = 35.5)
   (1) 176 g (2) 263 g (3) 303 g
   (4) 351 g (5) 527 g

7. The solubility product of the salt XY_3 at 25 °C is 4.32 × 10^{-10} mol^4 dm^{-12}. The concentration of Y^- in a saturated solution of XY_3 is
   (1) 2.0 × 10^{-3} mol dm^{-3} (2) 6.0 × 10^{-3} mol dm^{-3}
   (3) 1.1 × 10^{-2} mol dm^{-3} (4) 3.8 × 10^{-3} mol dm^{-3}
   (5) 4.0 × 10^{-3} mol dm^{-3}

8. Which of the following reactions is **not** likely to take place during nitration of benzene?
   (1) 
   (2) 
   (3) 
   (4) 
   (5) 

9. When PCl_3 reacts with an **equimolar quantity** of water, the products are
   (1) $POCl_3$ and HCl (2) H_3PO_4 and HCl
   (3) H_3PO_3 and HCl (4) H_3PO_4 and $POCl_3$
   (5) $POCl_3$ and H_2

10. The shape and electron pair geometry of F_4ClO^- ion are respectively
    (1) trigonal bipyramidal and square pyramidal.
    (2) square pyramidal and octahedral.
    (3) trigonal bipyramidal and octahedral.
    (4) square pyramidal and trigonal bipyramidal.
    (5) octahedral and square pyramidal.

11. Which of the following statements is **correct** with respect to an isolated system?
    (1) Boundary of the system allows matter to exchange.
    (2) Boundary of the system does not allow matter to exchange but allows heat to exchange.
    (3) Boundary of the system allows matter or heat to exchage but it does not allow work to exchange.
    (4) Boundary of the system does not allow matter, heat and work to exchange.
    (5) Boundary of the system allows matter, heat and work to exchange.

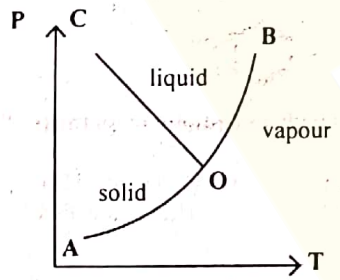
12. Which of the following statements regarding 3*d* elements is **false**?
(1) The electronegativity of 3*d* elements generally increases across the period from left to right.
(2) The first ionization energy of a 3*d* element involves the removal of a 4s electron.
(3) The melting points of 3*d* elements are not as high as the melting points of the 3*s* elements.
(4) The highest oxidation number for the first five 3*d* elements is equal to the total number of 4*s* and 3*d* electrons of the element.
(5) The densities of 3*d* elements are much higher than the densities of the 3*s* elements.

13. The density of an 18.0% (by mass) solution of $(NH_4)_2SO_4$ is 1.10 g cm^{-3}. The molarity of this $(NH_4)_2SO_4$ solution is (H=1, N = 14, O = 16, S = 32)
(1) 1.4 M (2) 1.5 M
(3) 1.7 M (4) 2.0 M
(5) 2.1 M

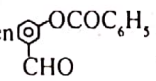
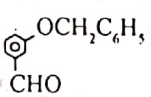
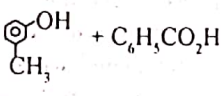
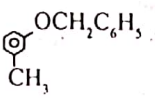
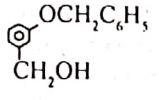
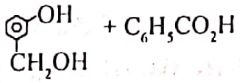
14. The standard enthalpy of combustion of C(s) is -393.5 kJ mol^{-1}. The standard enthalpy of formation values of CO(g) and H_2O(g) are -110.5 kJ mol^{-1} and -241.8 kJ mol^{-1} respectively. The standard enthalpy change of the reaction $CO_2(g)+H_2(g)\rightarrow CO(g)+H_2O(g)$ is
(1) 524.8 kJ mol^{-1} (2) -262.5 kJ mol^{-1}
(3) 41.2 kJ mol^{-1} (4) -41.2 kJ mol^{-1}
(5) 262.5 kJ mol^{-1}

15. The solubility product of the sparingly soluble hydroxide MOH is 1.0×10^{-8} mol^3dm^{-6}. The pH of a saturated solution of MOH is
(1) 4.0 (2) 6.0 (3) 8.0 (4) 10.0
(5) 12.0

16. Consider the phase diagram given below.



Which line segment/s gives/give the T, P conditions at which the liquid and solid phases are in equilibrium?
(1) OA (2) OB
(3) OC (4) AO and OB
(5) AO and OC

17. When  is reacted with Zn/Hg and conc. HCl, the product/products obtained is/are
(1) 
(2) 
(3) 
(4) 
(5) 

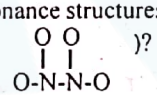
18. The gas **A** dissociates at temperature **T**, according to the elementary reaction, $A(g)\rightarrow 2B(g) + C(g)$ n-moles of gas **A** were kept in a rigid container and allowed to dissociate at temperature **T**. The initial pressure is P_0 and the pressure at time *t* is **P**. Identify which of the following terms is proportional to the rate of reaction at time *t*.
(1) $2P_0 - P$ (2) $3P_0 - 2P$
(3) $3P_0 - P$ (4) $P - P_0$
(5) $P_0 - 3P$

19. Consider the following two equilibria.

$MBr(s) + 2S_2O^{2-}_3(aq) \rightleftharpoons [M(S_2O_3)_2]^{3-}(aq) + Br(aq)$ equilibrium constant = K_1

$M^+(aq) + 2\,S_2O_3^{2-}(aq) \rightleftharpoons [M(S_2O_3)_2]^{3-}(aq)$ equilibrium constant = K_2

Given that $K_1 = 8.5$, and $K_2 = 1.7 \times 10^{13} mol^{-2}dm^6$, the solubility product of MBr is
(1) 1.7×10^{-13} mol^2 dm^{-6} (2) 5.0×10^{-13} mol^2 dm^{-6}
(3) 5.9×10^{-14} mol^2 dm^{-6} (4) 1.4×10^{-12} mol^2 dm^{-6}
(5) 1.4×10^{14} mol^2 dm^{-6}

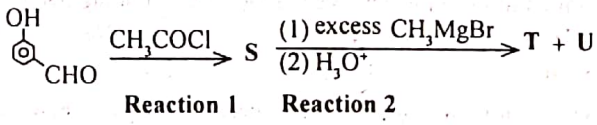
20. How many resonance structures can be drawn for the molecule N_2O_4 (skeleton )?
(1) 2 (2) 3
(3) 4 (4) 5
(5) 6

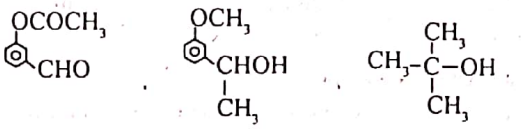
21. Which of the following statements is **false** with regard to Scandium (Sc)?
(1) The most stable positive oxidation state of Sc is +3.
(2) Sc^{3+} does not have *d* electrons.
(3) In general, compounds of Sc are white.
(4) Sc is the first of the 3*d* elements.
(5) Sc is a transition element.

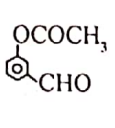
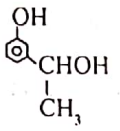
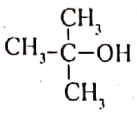
22. Oxalic acid ($H_2C_2O_4$) is a dibasic acid with $K_1 = 5.4 \times 10^{-2}$ mol dm^{-3} and $K_2 = 5.3 \times 10^{-4}$ mol dm^{-3}. What is the equilibrium constant for the reaction given below?

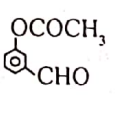
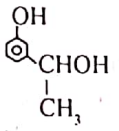
$$H_2C_2O_4(aq) + 2H_2O(l) \rightleftharpoons 2H_3O^+(aq) + C_2O_4^{2-}(aq)$$

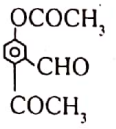
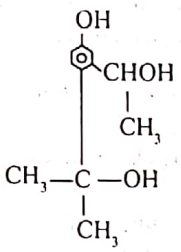
(1) 5.4×10^{-2} mol^2 dm^{-6} (2) 5.3×10^{-4} mol^2 dm^{-6}
(3) 2.9×10^{-5} mol^2 dm^{-6} (4) 1.0×10^{2} mol^2 dm^{-6}
(5) 9.8×10^{-3} mol^2 dm^{-6}

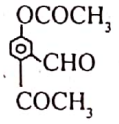
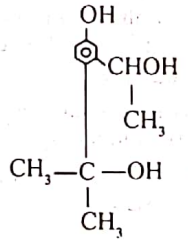
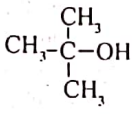
23. 
Reaction 1 **Reaction 2**

In the reaction scheme given above, the structures of **S**, **T** and **U** are respectively,
(1) 

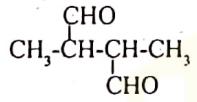
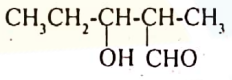
(2)   

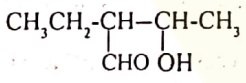
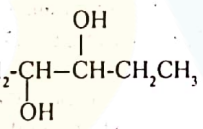
(3)   CH_3CO_2H

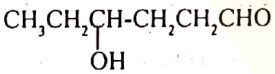
(4)   CH_3CO_2H

(5)   

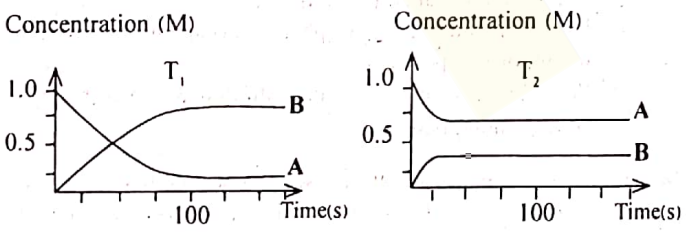
24. The structure of the compound arising from the self condensation of CH_3CH_2CHO, in the presence of aqueous NaOH is

(1)  (2) 

(3)  (4) 

(5) 

25. Variation of the concentration with time for the reaction **A⇌B** at temperatures T_1 and T_2 is given below. Note that only **A** is present at $t = 0$.

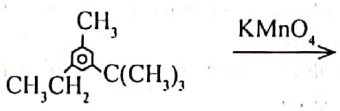


Which of the following statements is **true**?

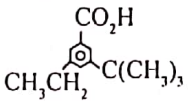
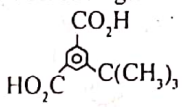
(1) $T_2 > T_1$ and forward reaction is endothermic
(2) $T_2 < T_1$ and forward reaction is endothermic
(3) $T_2 > T_1$ and forward reaction is exothermic
(4) $T_2 < T_1$ and forward reaction is exothermic
(5) $T_2 = T_1$ and forward reaction is endothermic

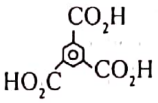
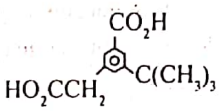
26. Identify the cation which gives
(i) a black precipitate with H_2S in the presence of OH^-.
(ii) no precipitate with H_2S in dilute HCl and
(iii) a blue solution with concentrated HCl.

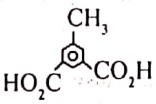
(1) Cu^{2+} (2) Mn^{2+} (3) Ni^{2+} (4) Fe^{3+} (5) Co^{2+}

27. 

The major product obtained from the reaction given above is

(1)  (2) 

(3)  (4) 

(5) 

28. The principal products obtained when Li, Na, K and Mg react with excess oxygen at atmospheric pressure are respectively.
(1) Li_2O, Na_2O, K_2O_2 and MgO
(2) Li_2O, Na_2O_2, KO_2 and MgO
(3) Li_2O, Na_2O_2, KO_2 and $Mg(O_2)_2$
(4) LiO_2, Na_2O, KO_2 and MgO_2
(5) Li_2O, Na_2O_2, KO_2 and MgO_2

29. What is the electromotive force of the following cell?

$$M(s)|M^{2+}(aq)||N^{3+}(aq)|N(s)$$

$E^0_{M^{2+}/M} = -0.72V$ $E^0_{N^{3+}/N} = 0.28V$

(1) 1.00 V (2) 0.44 V
(3) -1.00 V (4) -0.44 V
(5) 2.04 V

30. Consider the reaction given below.

$$3W(g) + X(g) \rightleftharpoons 2Y(g) + Z(g)$$

If the reaction was initiated by adding an equal number of moles of W and X, which of the following is **correct** at equilibrium?

(1) [Y] = [Z] (2) [Z] > [Y]
(3) [W] = [X] (4) [X] > [W]
(5) [X] < [W]

- For each of the questions **31** to **40**, one or more responses out of the four responses *(a)*, *(b)*, *(c)*, and *(d)* given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

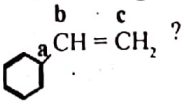
(1) if only *(a)* and *(b)* are correct.
(2) if only *(b)* and *(c)* are correct.
(3) if only *(c)* and *(d)* are correct.
(4) if only *(d)* and *(a)* are correct.
(5) if **any other** number or combination of responses is correct.

Summary of above Instructions

(1)	(2)	(3)	(4)	(5)
Only *(a)* and *(b)* are correct	Only *(b)* and *(c)* are correct.	Only *(c)* and *(d)* are correct.	Only *(d)* and *(a)* are correct.	**Any other** number or combination of responses is correct

31. Which of the following statements is/are **always true** about a spontaneous reaction that occurs at temperature **T**?
(a) Reaction must have a positive entropy change.
(b) Reaction must have a negative enthalpy change.

(c) Enthalpy change of the reaction must be negative if the entropy change is negative.
(d) Enthalpy change of the reaction must be negative if the entropy change is positive.

32. Which of the following statements is/are **true** regarding the molecule 

?

(a) All carbon atoms are sp^2 hybridized.
(b) All carbon, carbon bond lengths are equal.
(c) Carbon atoms labelled as **a**, **b** and **c** lie in a straight line.
(d) Carbon atom **a** and hydrogen atoms attached to carbons **b** and **c** lie on the same plane.

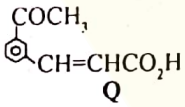
33. Which of the following statements is/are **false** with regard to the manufacture of NH_3 using N_2 and H_2 gases as raw materials?

(a) N_2 is obtained by the fractional distillation of liquid air.
(b) NH_3 formed is continuosly removed by liquefying it.
(c) The reaction between N_2 and H_2 is endothermic.
(d) The pressure and temperature used are **250** atm and **850** °C respectively.

34. Consider the following reaction taking place in a closed system.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -93.0 \text{ kJ mol}^{-1}$$

Which statement/statements given below is/are **correct** with regard to this reaction?
(a) Increase in pressure at constant temperature, increases the amount of product formed.
(b) Increase in temperature at constant pressure, decreases the amount of product formed.
(c) Use of a catalyst, increases the amount of product formed.
(d) Use of a catalyst, increases the activation energy of the reverse reaction.

35. Which of the following statements is/are **true** regarding compound **Q** ? 

Q

(a) **Q** can exist in two stereoisomeric forms.
(b) The product obtained when **Q** is reacted with Br_2/CCl_4 does **not** exhibit optical isomerism.
(c) The product obtained when **Q** is reacted with H_2 in the presence of **Pd** exhibits optical isomerism.
(d) The product obtained when **Q** is reacted with $NaBH_4$ exhibits optical isomerism.

36. Which of the following statements is/are **true** with regard to electromagnetic radiation of wavelength 200 nm?

(a) It has a higher frequency than radiation of wavelength 400 nm.
(b) It is in the visible region of the electromagnetic spectrum.
(c) In a vacuum, it has a higher velocity than radiation of wavelength 400 nm.
(d) Its photon has a higher energy than a photon of radiation of wavelength 100 nm.

37. Which of the following method/s can be used to prevent the oxidation of Fe^{2+} to Fe^{3+} in an aqueous solution?

$$O_2 + 4H^+ + 4e \rightarrow 2H_2O \quad E^o = 1.23V$$

$$E^o_{Fe^{3+}/Fe^{2+}} = 0.77V \quad E^o_{Fe^{2+}/Fe} = -0.44V \quad E^o_{Zn^{2+}/Zn} = -0.76V$$

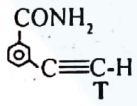
$$E^o_{Ag^+/Ag} = 0.80V$$

(a) Adding a small amount of Fe metal to the solution
(b) Adding a small amount of Zn^{2+} to the solution
(c) Adding a small amount of Ag metal to the solution
(d) Adding a small amount of Zn metal to the solution

38. Which of the following is/are **true** about the equilibrium given below?

$$KNO_3(s) + H_2O(l) \rightleftharpoons K^+(aq) + NO_3^-(aq)$$

(a) To observe the equilibrium, $KNO_3(s)$, $K^+(aq)$, $NO_3^-(aq)$ and $H_2O(l)$ must all be present.
(b) The expression for the equilibrium constant does not contain the terms $[KNO_3(s)]$ and $[H_2O(l)]$ because they can be considered as constants.
(c) Increasing $K^+(aq)$ concentration in the system drives the point of equilibrium to the right.
(d) Addition of $KNO_3(s)$ to the system drives the point of equilibrium to the right.

39. Which of the following statements is/are **true** regarding the compound **T**? 

T

(a) When **T** is heated with aqueous NaOH, ammonia is liberated.
(b) Ammonia is produced in the reaction of **T** with $NaNH_2$.
(c) Metallic silver is deposited as a silver mirror, when **T** is reacted with ammoniacal $AgNO_3$.
(d) An aldehyde is formed, when **T** is reacted with dilute H_2SO_4 in the presence of Hg^{2+} ions.

40. Which of the following statements is/are **true** regarding polymers?
(a) PVC is a thermosetting polymer.
(b) Nylon 6,6 is made by the polymerization of 1,6-diaminohexane and hexanedioic acid.
(c) Urea-formaldehyde and phenol-formaldehyde are both thermoplastic polymers.
(d) Polystyrene is made by the addition polymerization of styrene monomers.

• In question Nos. **41** to **50**, two statements are given in respect of each question. From the Table given below, select the response out of the responses (1), (2), (3), (4) and (5) that **best** fits the two statements and mark appropriately on your answer sheet.

Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement.
(2)	True	True, but does **not** explaind the first statement correctly
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	Second Statement
41.	Solid sulphur reacts with hot concentrated H_2SO_4 to give SO_3 and H_2O.	Hot concentrated H_2SO_4 acts as a dehydrating agent.
42.	$C_6H_5CH_2NH_2$ is more basic than $C_6H_5CH_2NHCOCH_3$	The lone pair of electrons on the nitrogen atom of an amide is delocalized onto the carbonyl group by resonance.
43.	When Zn^{2+} is added to a solution containing Cu^{2+}, metallic Cu is displaced.	The standard reduction potential of Cu^{2+} is more positive than the standard reduction potential of Zn^{2+}.
44.	The reaction of NH_3 with Na gives H_2 as a product, whereas the reaction of NH_3 with Cl_2 gives N_2 as a product.	NH_3 acts as an oxidizing as well as a reducing agent.
45.	The boiling point of 2,2-dimethylbutane is higher than the boiling point of n-hexane.	In molecules, as the surface area decreases the strength of dispersion forces decreases.

46.	All the molecules in as ideal gas move at the same speed.	There are no intermolecular attractive forces in an ideal gas.
47.	H_2O_2 is used in the manufacture of nitric acid from ammonia.	H_2O_2 always acts as an oxidizing agent.
48.	Benzene diazonium chloride reacts with phenol to give an orange coloured compound.	Diazonium salts act as nucleophiles.
49.	The rate of an elementary reaction increases with increasing concentration of reactants.	The rate of an elementary reaction is always linearly proportional to the concentrations of the reactants.
50.	Formation of ozone at the lower level in the atmosphere requires the presence of hydrocarbons.	Hydrocarbons react with oxygen in the presence of light to produce ozone.

The Periodic Table

1	1 H																2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	La-Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	Ac-Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub	113 Uut	...				

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

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General Certificate of Education (Adv.Level) Examination, August 2014

Chemistry II - Three hours

PART A - STRUCTURED ESSAY

*Answer **all four** questions on this paper itself. (Each question carries 10 marks.)*

1. (*a*) Arrange the following in the **decreasing** order of the property indicated in parenthesis.

(i) Li, Na, Mg, Al, Si (first ionization energy)

..... > ..... > ..... > ..... > .....

(ii) C, O, F, Cl (first electron affinity)

..... > ..... > ..... > .....

(iii) $BeCl_2$, $CaCl_2$, $BaCl_2$ (melting point)

..... > ..... > .....

(iv) NCl_3, $SiCl_4$, ICl_4^- (bond angle)

..... > ..... > .....

(v) H_2O, H_3O^+, OH^- (electronegativity of oxygen atom)

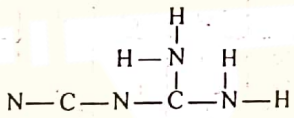
..... > ..... > .....

(vi) NO^+, FNO_2, ClNO, NH_2OH (N-O bond length)

..... > ..... > .....> .....

(3.0 marks)

(*b*) 2- Cyanoguanidine ($C_2H_4N_4$) is a widely used chemical in agriculture. The following questions (i) to (v) are based on 2-Cyanoguanidine. Its skeleton is given below



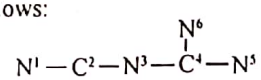
(i) Draw the **most acceptable** Lewis structure for this molecule.

(ii) Draw **four** resonance structures (excluding the structure drawn in (i) above) for this molecule.

(iii) State the following regarding the C and N atoms given in the table below:

I. electron pair geometry (arrangement of electron pairs) around the atom
II. shape around the atom
III. hybridization of the atom

The carbon and nitrogen atoms of 2-Cyanoguanidine are labelled as follows:



		C^2	N^3	C^4	N^5or N^6
I.	electron pair geometry				
II.	shape				
III.	hybridization				

(iv) Sketch the shape of the Lewis structure drawn in part (i) above indicating approximate values of the bond angles (show all bond angles other than those involving N-H bonds.)

(v) Identify the atomic/hybrid orbitals involved in the formation of the following σ-bonds in the Lewis structure drawn in part (i) above (numbering of atoms as in part (iii)).

I. N^1 - C^2 N^1 ....., C^2 .....
II. C^2 - N^3 C^2 ....., N^3 .....
III. N^3 - C^4 N^3 ....., C^4 .....

(5.0 marks)

(*c*) Consider the two chemical substances CH_3Cl (boiling point 249 K) and CH_3I (boiling point 316 K).

(i) Which substance has the larger dipole moment?

.....

(ii) Which substance has the stronger London dispersion forces?

.....

(iii) Which substance has the stronger total intermolecular attractive forces?

.....

(iv) Which type of intermolecular force is dominant in comparing these two substances?

.....

(electronegativity: H = 2.1, C = 2.5, I = 2.5, Cl = 3.0)

(2.0 marks)

2. (*a*) **X** is an element in the third period of the Periodic Table. Its first five successive ionization energies, in kJ mol^{-1}, are respectively, 577, 1816, 2744, 11577 and 14842. **X** reacts with both dilute HCl and dilute NaOH separately, liberating the same colourless and odourless diatomic gas.

(i) Identify element **X** .....

(ii) Write the ground state electronic configuration of **X.**

.....

(iii) Give the most stable positive oxidation state of **X.**

.....

(iv) Give balanced chemical equations for the reaction of element **X** with

I. dilute HCl .....

II. dilute NaOH .....

(v) **X** burns readily in air or O_2 to form an oxide. Write the formula of the oxide.

.....

(vi) Write the balanced chemical equation for the reaction of **X** when heated with $NaNO_3$ and dilute NaOH.

.....

.....

.....

(vii) Write the formula of the chemical species that the ion of **X** having the most stable oxidation state forms in an **aqueous** medium. Predict what you would expect to observe when a small amount of solid Na_2CO_3 is added to an aqueous solution of this ion.

.....

.....

(viii) Give **one** use of element **X**

.....

(5.0 marks)

(*b*) Test tubes labelled **A** to **E** contain solutions of $Mg(NO_3)_2$, Na_2CO_3, KCl, $ZnSO_4$ and $Pb(NO_3)_2$ (not in order). $BaCl_2$ and dilute NH_4OH solutions are added separately to portions of each solution. The observations are given in the table below.

Solution	$BaCl_2$ solution	dilute NH_4OH solution
A	a white precipitate soluble in hot water	a white precipitate
B	a white precipitate insoluble in dil. HCl	a white precipitate soluble in excess NH_4OH
C	a white precipitate soluble in dil. HCl	a clear solution
D	a clear solution	a clear solution
E	a clear solution	a gelatinous white precipitate

(i) Identify solutions **A** to **E**

A = ...

B = ...

C = ...

D = ...

E = ...

(ii) Write balanced chemical equations for the following reactions.

I. All the reactions forming precipitates (indicate the precipitates with an arrow (↓) in the equations)

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II. All the reactions involving dissolution of precipitates.

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(5.0 marks)

3. **Y** is a 1.00 M solution of a weak acid HA with a pH = 3.0 at 25 °C. A 100.0 cm^3 sample of this solution was placed in a shaking bottle and 100.0 cm^3 of an organic solvent was added. After shaking the bottle it was placed in a water bath at 25 °C for 30 minutes. Thereafter, the two layers were separated and the aqueous layer was labelled as solution **Z**. A 25.00 cm^3 sample of solution **Z** was titrated with 0.50 M NaOH using phenolphthalein as the indicator. The volume of NaOH required was 40.00 cm^3.

(i) Calculate the degree of dissociation, σ, of the weak acid in solution **Y** at 25 °C.

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(ii) Calculate the dissociation constant (K_a) of the acid HA at 25 °C.

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(iii) Calculate the degree of dissociation, α′, of the acid HA in solution **Z** at 25 °C

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(iv) Using the values of α and α′ calculated above, comment on the relationship between the degree of dissociation and concentration of the acid HA at 25 °C.

.....

.....

(v) Calculate the partition coefficient at 25 °C of the acid HA between water and the organic solvent. (The weak acid HA, does not associate or dissociate in an organic solvent. Disregard the dissociation of HA in aqueous medium.

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(vi) Calculate the pH of a mixture containing 25.00 cm^3 of solution **Y** and 25.00 cm^3 of 0.50 M NaOH solution.

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(10.0 marks)

4. (*a*) **A** and **B** are structural isomers of methylpentene with the molecular formula C_6H_{12}. **A** exhibits geometric isomerism while **B** exhibits optical isomerism. On hydrogenation, **A** and **B** yield the same compound **C** with the molecular formula C_6H_{14}. **C** does not exhibit optical isomerism. Draw the structures of **A**, **B** and **C** in the boxes given below (It is **not necessary** to draw the stereoisomeric forms).

A **B** **C**

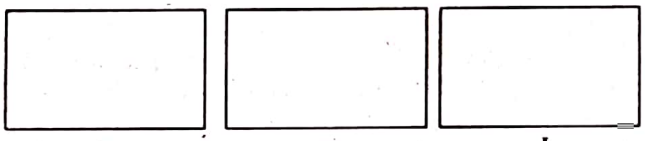
(1.5 marks)

(*b*) (i) Consider the following two reaction sequences (I and II) and draw the structures of the products **D, E, F, G, H** and **I** in the boxes given below.

I. $\mathbf{A} \xrightarrow[H_2O_2]{HBr} \mathbf{D} \xrightarrow{aq.KOH} \mathbf{E} \xrightarrow{PCC} \mathbf{F}$

II. $\mathbf{B} \xrightarrow[H_2O_2]{HBr} \mathbf{G} \xrightarrow{aq.KOH} \mathbf{H} \xrightarrow{PCC} \mathbf{I}$

D **E** **F**



G **H** **I**

(ii) Give a chemical test with the relevant observations to distinguish between **F** and **I**

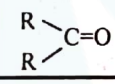
.....
.....
.....

(iii) Compound **E** is a structural isomer of **H**. Name the type of structural isomerism that is found between these two compounds.

.....

(4.0 marks)

(*c*) Draw the structures of the major products of the reactions given in the table below. Classify each of the reactions as nucleophilic addition (A_N), electrophilic addition (A_E), nucleophilic substitution (S_N), electrophilic substitution (S_E) or eliminaction (**E**), by writing A_N, A_E, S_N, S_E, **E** in the appropriate cages.

Reaction number	Reactant	Reagent	Major product	Reaction type
1	$C_2H_5CH{=}CHC_2H_5$	Br_2/CCl_4		
2		CH_3COCl/ anhydrous $AlCl_3$		
3	ROH	PCl_3		
4	RCH_2CH_2OH	anhydrous Al_2O_3/Δ		
5		RMgBr		

(2.5 marks)

(*d*) Write the mechanism for **Reaction No. 2.** Explain why the intermediate formed from benzaldehyde is stable in this reaction.

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(2.0 marks)

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General Certificate of Education (Adv.Level) Examination, August 2014

Chemistry II

- Universal gas constant R = 8.314 J K^{-1} mol^{-1}
- Avogadro constant N_A = 6.022 x 10^{23} mol^{-1}

PART B - ESSAY

Answer two questions only. (Each question carries **15** *marks.)*

5. (*a*) (i) State Raoult's law.

(ii) **A** and **B** form an ideal solution. This solution is in equilibrium with its vapour phase in a rigid container. The amounts of **A** and **B** in moles in the liquid phase are n_A and n_B respectively. The saturated vapour pressures of **A** and **B** at the temperature T are P^o_A and P^o_B respectively.

I. Calculate the partial pressure of **A** given that n_A = 0.10 mol, n_B = 0.20 mol, P^o_A = 1.00 x 10^4 Pa and P^o_B = 3.50 × 10^4 Pa.

II. Calculate the total pressure of the system.

(5.0 marks)

(*b*) The gas **C** dissociates into gases **D** and **E** according to the reaction given below.

$$C(g) \rightleftharpoons 2D(g) + E(g)$$

1.00 mol of **C** was introduced into a rigid container and allowed to reach equilibrium at temperature T_1. It was observed that 0.20 mol of **C** has dissociated at equilibrium and the pressure in the container was 1.00 x 10^5 Pa.

(i) Calculate the equilibrium constant in terms of partial pressures, K_P, for the above equilibrium writing the relevant expressions.

(ii) Calculate the equilibrium constant in terms of concentrations, K_C, if T_1 = 500 K.

(iii) When the temperature of the system was lowered to T_2 (T_2 = 300 K), it was observed that **D** is partially liquefied and is in equilibrium with its vapour. **C** and **E** remain as gases and are insoluble in the liquid phase of **D**. The saturated vapour pressure of **D** at 300 K is 5.00 x 10^2 Pa. The amount of **C** dissociated at T_2 is 0.10 mol. Calculate k_P.

(10.0 marks)

6. (*a*) Gas **A** decomposes according to the elementary reaction given below.

$$A(g) \rightarrow B(g) + C(g)$$

(i) Write the rate law for the reaction.

(ii) The above reaction was started by introducing 1.0 mol of **A** into a rigid container at 300 K. The initial pressure of 30 kPa increased to 32 kPa in 10 s. When the experiment was repeated at 400 K, using the same amount of **A**, the initial pressure of 40 kPa increased to 45 kPa in 10 s. Rate constants of the reaction at 300 K and 400 K are k_1 and k_2 respectively.

I. Calculate the amount of **A** decomposed in 10 s at 300 K

II. Calculate the amount of **A** decomposed in 10 s at 400 K

III. Giving reasons show that $k_2 > k_1$ **(5.0 marks)**

(*b*) Enthalpy and entropy data for the dissociation of the weak acid **HA** are given below.

	Enthalpy change kJ mol^{-1}	Entropy change J K^{-1} mol^{-1}
HA(aq) → A$^-$(aq) + H$^+$ (aq)	ΔH_1 = 1.0	ΔS_1 = 95.0
A$^-$(g) → A$^-$(aq)	ΔH_2 = -200.0	ΔS_2 = -2000.0
H$^+$ (g) → H$^+$ (aq)	ΔH_3 = -1100.0	ΔS_3 = -1200.0
HA (g) → HA(aq)	ΔH_4 = -150.0	ΔS_4 = -100.0

(i) Write the balanced chemical equation for the dissociation of **HA** in gas phase

(ii) Calculate the following for the dissociation of **HA** in gas phase

I. Enthalpy change

II. Entropy change

III. Gibbs energy change at 300 K

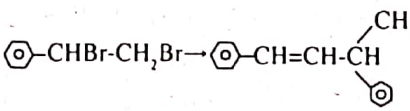
(iii) Comment on the spontaneity of the dissociation of **HA** in the gas phase at 300 K

(iv) Calculate the Gibbs energy change for the dissociation of **HA** in the aqueous phase at 300 K

(v) At what temperature does the Gibbs energy change of dissociation of **HA** in gas phase become equal to its Gibbs energy change of dissociation in the aqueous phase?

Note: Assume that ΔH and ΔS are independent of temperature. **(10.0 marks)**

7 (*a*) Using **only** the chemicals given in the list, show how you would carry out the following conversion



List of chemicals

H_2, Pd/$BaSO_4$/ Quinoline.
$NaBH_4$.
Na, alcoholic KOH.
$HgSO_4$, dil H_2SO_4.
PBr_3

(5.0 marks)

(*b*) Show how you would synthesize compound **B** using compound **A** as the **only** organic starting material.

CH_3CH_2OH **A** → $CH_3CHBrCHBrCH_3$ **B**

(7.0 marks)

(c) Draw the structures of the compounds **C** and **D** in the reaction sequence given below.

$$CH_3CH{=}CH_2 \xrightarrow{\text{conc. } H_2SO_4} C \xrightarrow[\Delta]{H_2O} D$$

It is observed that the same product **D** can be obtained directly by the reaction of $CH_3CH{=}CH_2$ with **dilute** H_2SO_4. Explain this observation by taking into account the fact that H_2O can act as a nucleophile **(3.0 marks)**

PART C - ESSAY

Answer two questions only. (Each question carries 15 marks.)

8. (a) The following question is based on the *s* and *p* block elements in the Periodic Table. Identify the chemical species **P, Q, R, S, T, U, V, W, X** and **Y** in the reaction scheme given below.

P (white solid) $\xrightarrow{\Delta}$ **Q** (white solid) + **R** (colourless gas)

Q $\xrightarrow{\text{dil. HCl}}$ **S** (reddish brown gas) + other products

$Q + NH_4Cl(s) \xrightarrow{\Delta} T$ (white residue that gives a bright yellow colour in the flame test) + U(colourless gas) + water vapour

R + **V** (colourless gas) $\xrightarrow[\text{temperature}]{\text{high}}$ **U** + water vapour

$Ca(s) + U \xrightarrow{\Delta} W$ (white solid)

$W + H_2O(l) \longrightarrow V$ + another product

$Mg(s) + R \xrightarrow{\Delta} X$ (white solid)

$X + H_2O(l) \longrightarrow Y$ (turns phenolphthalein pink)

(5.0 marks)

(b) Tests (1), (2) and (3) were carried out with an **aqueous solution** containing an inorganic covalent compound **Z**. The tests and observations are given below.

	Test	Observation
(1)	Added an acidified suspension of MnO_2 to the **aqueous solution.**	a pale pink solution with evolution of O_2 gas
(2)	Passed H_2S gas through the **aqueous solution.**	a pale yellow (sometimes white) turbidity
(3)	Passed SO_2 gas through the aqueous solution. Removed excess SO_2 and added a solution of $BaCl_2$	a white precipitate insoluble in dilute HCl

(i) Identify **Z**

(ii) Give balanced chemical equations for the reactions that occur in tests (1), (2), and (3).

(iii) Give **two** uses of **Z.**

(iv) What is the most important intermolecular force that is present in **Z** ? **(5.0 marks)**

9. The following procedure was used to determine the thickness of a layer of chromium coated on one surface of a rectangular sheet of an inert material

Procedure :

A dilute acid was used to dissolve the chromium in a 8.0 cm x 5.0 cm rectangular sample of the given sheet. The resulting Cr^{3+}, was oxidized with $S_2O_8^{2-}$ (peroxydisulfate ion) in neutral medium as given below

$$S_2O_8^{2-}(aq) + Cr^{3+}(aq) + H_2O(l) \rightarrow Cr_2O_7^{2-}(aq) + H^+(aq) + SO_4^{2-}(aq)$$

After removal of excess $S_2O_8^{2-}$, the solution was acidified and an excess of ferrous ammonium sulfate, $(Fe(NH_4)_2(SO_4)_2.6H_2O)$ 3.10 g was added. The unreacted Fe^{2+} was then titrated with 0.05 M $K_2Cr_2O_7$ solution. The volume required was 8.50 cm^3.

(i) Give balanced chemical equations for the reactions of

I. $Cr^{3+}(aq)$ with $S_2O_8^{2-}(aq)$

II. $Fe^{2+}(aq)$ with $Cr_2O_7^{2-}(aq)$

(ii) Calculate the thickness of the chromium layer on the sample

(Density: Cr = 7.2 g cm^{-3}. Relative atomic mass: Fe = 56, Cr = 52, S = 32, O = 16, N = 14, H = 1)

(5.0 marks)

(9) (a) The following questions are based on the extraction of iron using the Blast Furnace.

(i) Give the common names along with their chemical formulae of the iron ore and other raw materials used in the extraction of iron.

(ii) Discuss briefly the function of each of the raw materials, except the iron ore. Use balanced chemical equations where applicable.

(iii) Write balanced chemical equations to show the stepwise conversion of iron ore to iron in the Blast Furnace

(iv) Write the name given to the molten iron formed at the bottom of the Blast Furnace and give its approximate composition.

(v) Indicate the changes in composition required to convert the iron obtained from the Blast Furnace to stainless steel. State briefly how this is done.

(vi) Calculate the mass of the gas, (identified in part (iii)) in kg used in the stepwise conversion of iron ore to produce 2000 kg of iron

(vii) The waste gas mixture that travels up and comes out of the Blast Furnace is known as blast furnace gas or flue gas. State the principal gases present in the mixture and identify the predominant gas.

(Relative atomic mass: Fe = 56, O = 16, C = 12)

(7.5 marks)

(b) (i) State **two** major carbon species found in each of the following.

I. atmosphere

II. lithosphere (earth's crust)

III. hydrosphere

(ii) State **five** natural processes that provide and remove carbon species to and from the atmosphere

(iii) Explain how human activities increase the carbon content in the atmosphere.

(iv) State **two** global environmental issues that are caused by the elevation of carbon content in the atmosphere

(v) Name the chemical species/class of chemical species that are responsible for the environmental issues you mentioned in part (iv)

(vi) Write **two** detrimental effects caused by **each** of the environmental issues stated in part (iv), on global climate/human health **(7.5 marks)**

10. (a) (i) A domestic bleaching agent (hereafter referred to as bleaching solution) contains equal mole amounts of sodium hypochlorite (NaOCl) and Cl^-. The amount of Cl_2 gas liberated by the action of excess dilute acids on a sample of bleaching solution is called the 'available chlorine' of that sample. This is shown by the reaction below.

$ClO^-(aq) + 2H^+(aq) + Cl^-(aq) \rightarrow Cl_2(g) + H_2O(l)$

Generally, the 'available chlorine' of a bleaching solution is expressed as the amount of Cl_2 gas liberated from 100 g of the bleaching solution. The following procedure was used to determine the 'available chlorine' in a bleaching solution

Procedure:

A 25.0 cm^3 sample of the bleaching solution was diluted to 250.0 cm^3 in a volumetric flask with distilled water. To a 25.0 cm^3 sample of the diluted solution, acetic acid and excess **KI** were added. The I_2 liberated was then titrated with 0.30 M $Na_2S_2O_3$ solution using starch as the indicator. The volume required was 19.0 cm^3.

I. Write balanced chemical equations for the reaction of $ClO^-(aq)$ with $I^-(aq)$ and the reaction of I_2 with $Na_2S_2O_3$.

II. Calculate the percentage of 'available chlorine' by mass in the bleaching solution. (Density of the bleaching solution = 1.2 g cm^{-3}. Relative atomic mass: Cl = 35.5)

(ii) The following questions are based on the transition metal Fe and its compounds

I. Write the ground state electronic configuration of Fe.

II State the **two** most common positive oxidation states of Fe.

III. Aqueous $FeSO_4$ reacts with excess **KCN** to give a yellow octahedral ionic complex, **G**. **G** does not contain the elements H, O and S. Write the structural formula of **G**

IV Give the IUPAC name of **G**.

V **G** reacts with 30% aqueous HNO_3 to give a red-brown octahedral ionic complex, **L**. The oxidation state of Fe remains unchanged during this reaction. The molecular formula of **L** is $FeK_2C_6N_6O$. Write the structural formula of **L**.

VI The reaction taking place in part (V) above can be described as a ligand substitution reaction in an octahedral complex. From the list given below, identify the entering group and the leaving group, with their correct charges, in this substitution reaction.

N_2, NO, NO^+, NO_2^-, NO_3^-, CN^-, CO **(7.5 marks)**

(b) Waste water generated in an industrial process (pH = 7.0) contains a coloured compound **D**. A treatment plant is designed to remove the colour by electrochemically oxidizing this compound. Electrochemical oxidation of compound **D** in the aqueous medium takes place as follows.

$D(aq) \rightarrow A^{2+}(aq) + B(aq) + 2e$

$2H_2O(l) + 2e \rightarrow H_2(g) + 2OH^-(aq)$

The concentration of compound **D** in the waste water was found to be 0.001 mol dm^{-3}.

(i) Calculate the time required for complete electrochemical oxidation of compound **D** in a 1.0 dm^3 sample of the waste water by an electrolytic cell consisting of two Pt electrodes, using a constant current of 100 mA.

(Charge of 1.0 mol of electrons = 96500 C)

(ii) If $A(OH)_2$ is completely ionized in the aqueous medium, calculate the pH of the waste water sample after the electrochemical oxidation.

(iii) If the above industry releases waste water containing compound **D** at a rate of 10 $dm^3 \cdot s^{-1}$, calculate the minimum current that must be supplied to the electrolytic cell in order to completely oxidize compound **D** **(7.5 marks)**

The Periodic Table

1	1 H																2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	La-Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	Ac-Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub	113 Uut	...				

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

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General Certificate of Education (Adv.Level) Examination, August 2014

Chemistry - I

2014 - ANSWERS

01	1	2	**3**	4	5
02	1	2	3	4	**5**
03	1	**2**	3	4	5
04	1	2	3	4	**5**
05	1	2	3	**4**	5
06	1	**2**	3	4	5
07	1	**2**	3	4	5
08	1	2	**3**	4	5
09	**1**	2	3	4	5
10	1	**2**	3	4	5
11	1	2	3	**4**	5
12	1	2	**3**	4	5
13	1	**2**	3	4	5
14	1	2	**3**	4	5
15	1	2	3	**4**	5
16	1	2	**3**	4	5
17	1	**2**	3	4	5
18	1	2	**3**	4	5
19	1	**2**	3	4	5
20	1	2	**3**	4	5
21	1	2	3	4	**5**
22	1	2	**3**	4	5
23	1	**2**	3	4	5
24	1	**2**	3	4	5
25	1	2	**3**	4	5

26	1	2	3	4	**5**
27	1	**2**	3	4	5
28	1	**2**	3	4	5
29	**1**	2	3	4	5
30	1	2	3	**4**	5
31	1	2	3	4	**5**
32	1	2	3	**4**	5
33	1	2	**3**	4	5
34	**1**	2	3	4	5
35	1	2	3	**4**	**5**
36	1	2	3	4	**5**
37	1	2	3	**4**	5
38	**1**	2	3	4	5
39	**1**	2	3	4	5
40	1	2	3	4	**5**
41	1	2	3	**4**	5
42	**1**	2	3	4	5
43	1	2	3	**4**	5
44	**1**	2	3	4	5
45	1	2	3	**4**	5
46	1	2	3	**4**	5
47	1	2	3	4	**5**
48	1	2	**3**	4	**5**
49	1	2	**3**	4	5
50	1	2	3	4	**5**

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General Certificate of Education (Adv.Level) Examination, August 2014

Chemistry - II

PART A - STRUCTURED ESSAY

Answer all four questions on this paper itself. (Each question carries 10 marks)

1. (a) (i) Si > Mg > Al > Li > Na

(ii) Cl > F > O > C

(iii) $BaCl_2 > CaCl_2 > BeCl_2$

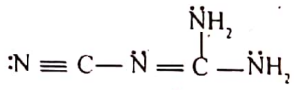
(iv) $SiCl_4 > NCl_3 > ICl_4^-$

(v) $H_3O^+ > H_2O > OH^-$

(vi) $NH_2OH > FNO_2 > ClNO > NO^+$

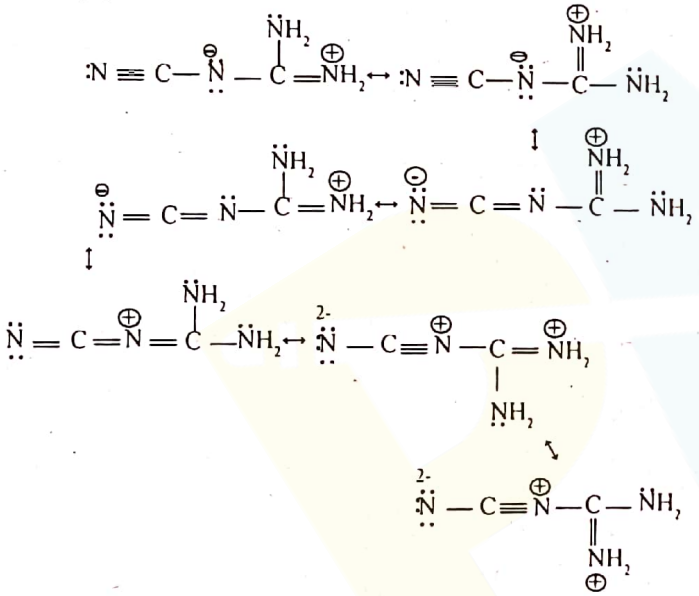
(05 × 6 = 30 Marks)

(b) (i)



(8 Marks)

(ii)



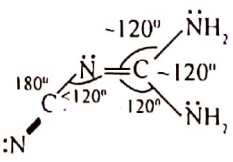
If more than four are given consider the first four (04 × 4 = 16 Marks)

(iii)

		C^2	N^3	C^4	N^5 or N^6
I	electron pair geometry	linear	trigonal planar	trigonal planar	Tetahedral
II	shape	linear	angular	trigonal planar	Pyramidal
III	hybridization	sp	sp^2	sp^2	sp^3

(01 × 12 = 12 Marks)

(iv)



sketch (03 marks)
angles (01 × 5 = 05 marks)

<120° - till 115° is accepted ~180° ± 2, ~120° ± 2 is accepted if b(i) is incorrect, no marks for b (iv)

08 Marks

(v) I. N^1 (2P a.o. **or** SP h.o), C^2 (SP h.o.)

II. C^2 (Sp h.o.), N^3 (SP^2 h.o.)

III. N^3 (SP^2 h.o.), C^4 (SP^2 h.o.)

(01 × 6 = 06 Marks)

(c) (i) CH_3Cl

(ii) CH_3I

(iii) CH_3I

(iv) London dispersion forces or London forces

(05 × 4 = 20 Marks)

2. (a) (i) Al or aluminium (05)

(ii) $1S^2\ 2S^2\ 2P^6\ 3S^2\ 3P^1$ (05)

(iii) +3 or +III (05)

(iv) I.

$2Al+6HCl \rightarrow 2AlCl_3+3H_2$ or $2Al+6HCl \rightarrow 2Al^{3+}+6Cl^-+3H_2$ (05)

II. $2Al+2H_2O+2NaOH \rightarrow 2NaAlO_2+3H_2$ or

$2Al+6H_2O+2NaOH \rightarrow 2NaAl(OH)_4+3H_2$ (05)

note: $NaAl(OH)_4$, can be given as $NaAlO_2.2H_2O$

(v) Al_2O_3 (05)

(vi) $NO_3^-(aq)+6H_2O(l)+8e \rightarrow NH_3(g)+9OH^-(aq)$

$Al(s)+4OH^-(aq) \rightarrow AlO_2^-+2H_2O(l)+3e$

$3NO_3^-(aq)+2H_2O(l)+8Al(s)+5OH^-(aq) \rightarrow 3NH_3(g)+8AlO_2^-(aq)$ (05)

note if only correct half reactions are given award 02+02 marks if metal has not been identified correctly as Al, no marks for (i) - (viii)

(vii) $[Al(H_2O)_6]^{3+}$ or $[Al(H_2O)_5(OH)^{2+}$ (05)
Evolution of gas bubbles (05)

(viii) To make aircraft bodies, cooking utensils, cans for drinks, electrical power cables, alloys, aluminium paints (any one) (05)

(05 × 10 = 50 Marks)

(b) (i) A = $Pb(NO_3)_2$ (04)
B = $ZnSO_4$ (04)
C = Na_2CO_3 (04)
D = KCl (04)
E = $Mg(NO_3)_2$ (04)

(20 Marks)

(ii) I $pb(NO_3)_2 + BaCl_2 \rightarrow pbCl_2\downarrow + Ba(NO_3)_2$ (04)
$pb(NO_3)_2 + 2NH_4OH \rightarrow pb(OH)_2\downarrow + 2NH_4NO_3$ (04)
$ZnSO_4 + BaCl_2 \rightarrow BaSO_4\downarrow + ZnCl_2$ (04)
$ZnSO_4 + 2NH_4OH \rightarrow Zn(OH)_2\downarrow + (NH_4)_2SO_4$ (04)
$Na_2CO_3 + BaCl_2 \rightarrow BaCO_3\downarrow + 2NaCl$ (04)
$Mg(NO_3)_2 + 2NH_4OH \rightarrow Mg(OH)_2\downarrow + 2NH_4NO_3$ (04)

(Note : Deduct 01 mark per reaction if ↓ is not shown)

II. $PbCl_2(s) \xrightarrow{\Delta} Pb^{2+}(aq) + 2Cl^-(aq)$ or $PbCl_2(aq)$ (01)

$Zn(OH)_2 + 4NH_4OH \rightarrow [Zn(NH_3)_4](OH)_2 + 4H_2O$ or

$Zn(OH)_2 + 4NH_3 \rightarrow [Zn(NH_3)_4](OH)_2$ or

$Zn(OH)_2 + 6NH_4OH \rightarrow [Zn(NH_3)_6](OH)_2 + 6H_2O$ or

$Zn(OH)_2 + 6NH_3 \rightarrow [Zn(NH_3)_6](OH)_2$ (03)

$BaCO_3 + 2HCl \rightarrow BaCl_2 + CO_2 + H_2O$ (02)

(30 Marks)

3. (i) Consider solution Y

$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$ (05)

or

$HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$

Concentrations $C(1-\alpha)$ $C\alpha$ $C\alpha$ (04 + 01)
mol dm^{-3}

pH = 3.0

pH = $-\log[H^+(aq)]$ (05)

$[H^+]$ = 1.0×10^{-3} mol dm^{-3} (04 + 01)

$[H^+] = C\alpha$

$\alpha = \frac{[H^+]}{C} = \frac{1 \times 10^{-3} \text{ mol dm}^{-3}}{1.0 \text{ mol dm}^{-3}} = 1 \times 10^{-3}$

(04 + 01)

(25 Marks)

(ii) Acid dissociation Constant, $K_a = \frac{[H^+(aq)][A^-(aq)]}{[HA(aq)]}$ (05)

$K_a = \frac{C\alpha \times C\alpha}{C(1-\alpha)}$

Assuming $1 - \alpha \approx 1$. (05)

$K_a = C\alpha^2 = 1.0 \text{ mol dm}^{-3} \times (1.0 \times 10^{-3})^2$

$K_a = 1.0 \times 10^{-6}$ mol dm^{-3} (04 + 01)

(15 Marks)

(iii) Concentration of HA in solution Z

$[HA]_Z = \frac{0.50 \text{ mol dm}^{-3} \times 40.00 \text{cm}^3}{25.00 \text{ cm}^3}$

$[HA]_Z$ = 0.80 mol dm^{-3} (04 + 01)

using $K_a = C(\alpha')^2$

α' = 1.118×10^{-3} or 1.12×10^{-3} or 1.1×10^{-3}

(04 + 01)

(10 Marks)

(iv) When the concentration of the acid is decreased its amount (degree) of dissociation is increased.

(10)

(10 Marks)

(v) partition coefficient $K = \frac{[HA]_{aq}}{[HA]_{org}}$ or $K = \frac{[HA]^{org}}{[HA]_{aq}}$ (05)

$K = \frac{0.8 \text{ mol dm}^{-3}}{(1.0 - 0.8) \text{ mol dm}^{-3}} = 4$ or

$K = \frac{(1.0 - 0.8) \text{ mol dm}^{-3}}{0.8 \text{ mol dm}^{-3}} = \frac{1}{4} = 0.25$

(04 + 01)

(10 Marks)

(vi) when NaOH is added.

Concentration of HA in the mixture

$= \frac{1.0 \text{ mol dm}^{-3} \times 25.00 \text{ cm}^3 - 0.50 \text{ mol dm}^{-3} \times 25.00 \text{ cm}^3}{50.00 \text{ cm}^3}$ (04 + 01)

$= 2.5 \times 10^{-1}$ mol dm^{-3} (04 + 01)

H^+ concentration

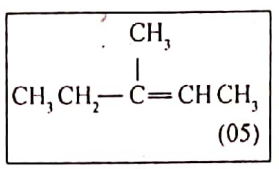
$[H^+] = \frac{Ka[HA]}{[A^-]} = \frac{1.0 \times 10^{-6} \text{ mol dm}^{-3} \times 2.5 \times 10^{-1} \text{ mol dm}^{-3}}{2.50 \times 10^{-1} \text{ mol dm}^{-3}} = 1.00 \times 10^{-6} \text{ moldm}^{-3}$

(04 + 01)

pH = $-\log[H^+]$ = 6.0 (04 + 01)

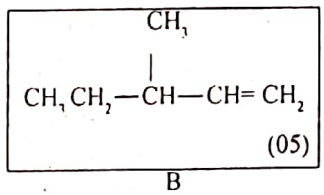
Note Correct argument showing that $[HA] = [A^-]$, awrd full marks. use of Henderson equation to show that $[HA] = [A^-]$ is also accepted **(30 Marks)**

4 (a)



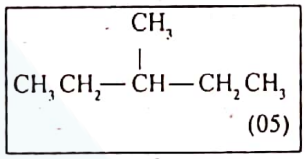
(05)

A



(05)

B

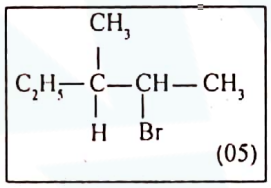


(05)

C

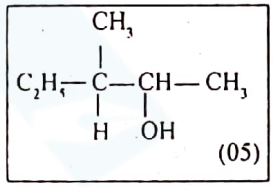
(15 Marks)

(b) (i)



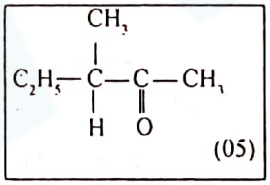
(05)

D



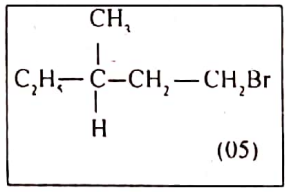
(05)

E



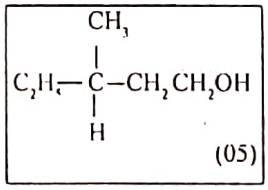
(05)

F



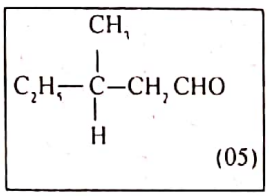
(05)

G



(05)

H



(05)

I

(30 Marks)

(ii) Silver mirror test/Tollens reagent/Ammonical Silver nitrate (02)

I gives a Silver mirror (but not F) (01+02)

or

Fehling test (02)

I gives a Brick red precipitate (but not F) (01+02)

or

Acidic $KMnO_4$ (02)

I decolorizes the solution (but not F) (01 + 02)

or

Acidic $K_2Cr_2O_7$ (02)

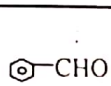
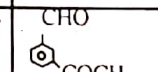
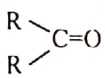
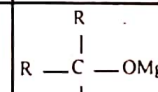
I turns the solution green (but not F) 01 +02

(05 marks)

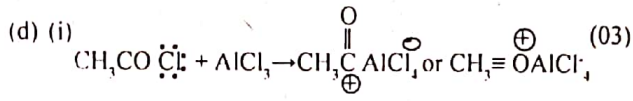
(iii) Position isomerism (05)

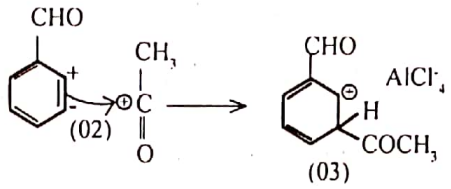
(05 marks)

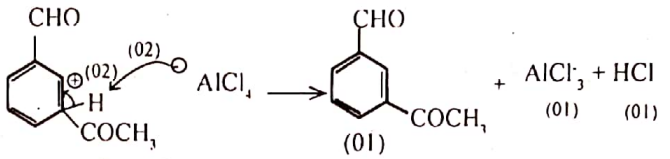
(c)

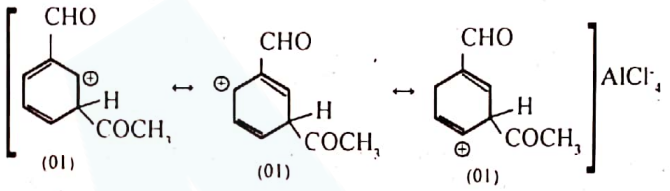
Reaction number	Reactant	Regent	Major Product	Reaction-tupe
1	$C_2H_5CH{=}CHC_2H_5$	Br_2/CCl_4	$C_2H_5-\underset{Br}{CH}-\underset{Br}{CH}-C_2H_5$ (03)	A_E (02)
2		CH_3COCl/ Anhydrous $AlCl_3$	 (03)	S_E (02)
3	ROH	PCl_3	RCl (03)	S_N (02)
4	RCH_2CH_2OH	Anhydrous Al_2O_3/Δ	$RCH{=}CH_2$ (03)	E (02)
5		RMgBr	 (03)	A_N (02)

(25 marks)

(d) (i)  (03)

(ii) 

(iii) 



Intermediate carbocation formed is stabilized by delocalization of the positive charge or resonance (02)

Note : Full marks can be awarded for the correct answer even if $AlCl_4^-$ is not given **(20 marks)**

PART B - ESSAY

5. (a) (i) In an ideal solution (at equilibrium with its vapour). the vapour pressure of a component is equal to its saturated vapour pressure times its mole fraction in solution.

or

In an ideal binary solution (at equilibrium with its vapour), the relative depression of the vapour pressure of one component is equal to the mole fraction of the other component in the solution.

or

The vapour pressure of a component in an ideal solution (in equilibrium with its vapour) is proportional to its mole fraction in the solution.

or

In the form of an equation with all the terms defined

(15 marks)

Ideal gas behavior in gas phase is assumed

(ii) I $P_A = P^0_A x_A$

$x_A = \frac{0.1(mol)}{(0.1 + 0.2)(mol)}$ (04 + 01)

$P_A = \frac{1.00 \cdot 10^5 Pa \times 0.1(mol)}{(0.1 + 0.2)(mol)}$ (04 + 01)

$P_A = 3.33 \cdot 10^5 Pa$ (04 + 01)

II $x_B = \frac{0.2(mol)}{(0.1 + 0.2)(mol)}$ (04 + 01)

$P_B = \frac{3.50 \cdot 10^5 Pa \times 0.2(mol)}{(0.1 + 0.2)(mol)} = 2.33 \times 10^5 Pa$ (04 + 01)

$P_{total} = P_A + P_B$ (05)

$P_{total} = 2.66 \cdot 10^5 Pa$ (04 + 01)

5(a) 50 Marks

(b) (i) $C(g) \rightleftharpoons 2D(g) + E(g)$

at equilibrium $(1 - \alpha)$ 2α α mol (05)

or

(1.0 - 0.2) mol 2 × 0.2 mol 0.2 mol

Note : Award 05 marks. only if unit is given

$K_p = \frac{P^2_D \times P_E}{P_C}$ (10)

Partial pressures.

$P_C = P_{total} \times x_C$. $P_D = P_{total} \times x_D$. $P_E = P_{total} \times x_E$ (05 x 03)

or

$P_C = \frac{P_{total} \times 0.8\ mol}{1.4\ mol}$. $P_D = \frac{P_{total} \times 0.4\ mol}{1.4\ mol}$;

$P_E = \frac{P_{total} \times 0.2\ mol}{1.4\ mol}$

$K_p = \frac{\left(1.00 \cdot 10^5 Pa \times \frac{0.4}{1.4}\right)^2 \left(1.00 \times 10^5 Pa \times \frac{0.2}{1.4}\right)}{\left(1.00 \cdot 10^5 Pa \times \frac{0.8}{1.4}\right)}$ (04 + 01)

$K_p = 2.04 \cdot 10^8 Pa^2$ or $2.0 \cdot 10^8 Pa^2$ (04 + 01)

(ii) $K_p = K_c (RT)^{\Delta n}$ (05)

$K_p = K_c (RT)^2$ or for the recognition of $\Delta n = 2$ (05)

$K_C = \frac{KP}{(RT)^2} = \frac{2.04 \times 10^8 \text{ Pa}^2}{(8.314 \text{ J mol}^{-1} \text{ k}^{-1} \times 500\text{k})^2}$ (04 + 01)

$K_C = 1.18 \times 10 \text{ mol}^2 \text{ m}^{-6}$ (04 + 01)

(iii) $C(g) \rightleftharpoons 2D(g \& l) + E(g)$

$(1-\alpha \quad 2\alpha \quad \alpha)$mol at equilibrium

(1.0 - 0.1) mol 2 × 0.1 mol (liq & vap) 0.1 mol

Total number of moles in gas phase = n (05)

New partial pressures,

$P_C = P_{total} \times x_C$, $P_E = P_{total} \times x_E$ (05 x 02)

or

$P_C = \frac{P'_{total} \times 0.9 \text{ mol}}{n \text{ mol}}$ $P_E = \frac{P'_{total} \times 0.1 \text{ mol}}{n \text{ mol}}$

$P_D = P^o_D$ (For the recognition that P_D is equal to saturated vapour pressure of D) (15)

Note : For detailed calculation of partial pressures, Award 10 marks for stating that the volume of the liquid phase is negligible. If the partial pressures have been calculated, award 04 + 01 for each $P_C = 3.86 \times 10^5$ Pa and $P_E = 4.28 \times 10^4$ Pa

If the ratio $P_E/P_C = 1/9 = 0.111$ is directly calculated, award 08 + 02 marks

If saturated vapour pressure of D is not used for P_D do not award marks beyound this step.

$K_p = \frac{(5.00 \times 10^2)^2 (P_{total} \times \frac{0.4}{n})}{(P_{total} \times \frac{0.9}{n})}$ (04 + 01)

$K_p = \frac{(5.0 \times 10^2 \text{ Pa})^2}{9}$

$K_p = 2.78 \times 10^4 \text{ Pa}^2$ (04 + 01)

5(b) 100 Marks

6. (a) (i) Rate = K [A] (10)

(ii) i.

$A \longrightarrow B + C$

At t = 0 s n - - mol (02)

At t = 10 s n(1-α) nα nα mol (03)

Note : Amounts can be given as concentrations, mol dm^{-3} Ideal gas behavior in gas phase is assumed. At 300 K

Total amount of gases after 10 s = n (1 + α) mol

Initially, $P = \frac{n}{v} RT$

$30 \times 10^3 \text{ Pa} = \frac{n}{v} RT$ ——— (1) (02)

After 10 s; $32 \times 10^3 \text{ Pa} = \frac{n(1+\alpha)}{v} RT$ ——— (2) (03)

from (2) / (1) $\frac{32}{30} = 1 + \alpha$

$\alpha = 1/15$ or $n\alpha = 1/15$ mol (04 + 01)

II. At 400 K

Total amount of gases after 10s = $n(1 + x')$ mol

Initially $40 \times 10^3 \text{ Pa} = \frac{n}{v} RT'$ ——— (3) (02)

After 10 s $45 \times 10^3 \text{ Pa} = \frac{n(1+\alpha')RT'}{v}$ ——— (4) (03)

From (4) / (3): $\frac{45}{40} = 1 + \alpha'$

$\alpha' = 1/8$ or $n\alpha' = 1/8$ mol (04 + 01)

III. Rate at 300 K, using initial concentration of A (Rate Constant at 300K is K_1)

$\text{Rate}_{300\text{K}} = \frac{\Delta[A]}{\Delta t} = K_1[A]$

$\frac{n/15v}{t} = K_1\left(\frac{n}{v}\right)$ ——— (5) (04 + 01)

Rate at 400 K, using initial concentration of A (Rate constant at 400 K is K_2)

$\text{Rate}_{400\text{K}} = \frac{\Delta[A]}{\Delta t} = K_2[A]$

$\frac{n/8v}{t} = K_2\left(\frac{n}{v}\right)$ ——— (6) (04 + 01)

From (6) / (5) $K_2/K_1 = 15/8$, $K_2 > K_1$ (05)

Full marks for III if correct arguments are used to show that $K_2 > K_1$ for the same initial concentration, the concentration change of A in 10s (or in constant time) is large at 400K (high temperature) compared to that at 300K (low temperature). Therefore K_2 must be greater than K_1.

(15 Marks)

For correct argument without all the facts, e.g. Rate is increased when the temperature is increased, Therefore, $K_2 > K_1$ (only 05 marks)

6(a) 50 Marks

(b) (i) $HA(g) \longrightarrow H^+(g) + A^-(g)$ (05)

(physical states are required, equilibrium arrows are accepted.)

(ii) I. Entropy change

$HA(g) \xrightarrow{\Delta H_5} H^+(g) + A^-(g)$

$\downarrow \Delta H_4$ $\downarrow \Delta H_3$ $\downarrow \Delta H_2$

$HA(aq) \xrightarrow{\Delta H_1} H^+(aq) \cdot A^-(aq)$ (04)

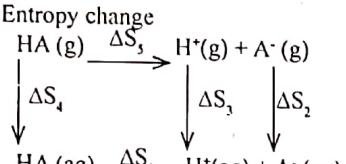
$\Delta H_5 = \Delta H_4 + \Delta H_1 - \Delta H_2 - \Delta H_3$

$= (-150.0 + 1.0 + 200.0 + 1100.0) \text{kJ mol}^{-1}$

(03+01) x4

$\Delta H_5 = 1151.0 \text{ kJ mol}^{-1}$ (04+01)

II. Entropy change



(04)

$\Delta S_5 = \Delta S_4 + \Delta S_1 - \Delta S_2 - \Delta S_3$

$= (-100.0 + 95.0 + 2000.0 + 1200.0) JK^{-1}mol^{-1}$ (03+01) ×4

$\Delta S_5 = 3195\ JK^{-1}\ mol^{-1}$ or $3.195\ kJ\ K^{-1}\ mol^{-1}$ (04+01)

III. Gibbs energy change at 300 K.
For a closed system at constant Pressure.

$\Delta G = \Delta H - T\Delta S$ (05)

$= 1151.0 kJ\ mol^{-1} - 300k\ 3.195\ kJ\ K^{-1}\ mol^{-1}$

$= 192.5\ kJ\ mol^{-1}$ (04+01)

Note : no marks for $\Delta G^0 = \Delta H^0 - T\Delta S^0$

(iii) Gibbs energy change for the dissociation of HA in gas phase at 300 K is positive.

Therefore, dissociation of HA in gas phase at 300K is not spontaneous. (10)

(iv) For the dissociation of HA in aqueous phase at 300 K

$\Delta H_1 = 1.0\ KJ\ mol^{-1}$ and $\Delta S_1 = 95.0\ JK^{-1}\ mol^{-1}$

$\Delta G_1 = 1.0\ kJ\ mol^{-1} - 300k\ 95x10^{-3}\ kJ\ K^{-1}\ mol^{-1}$ (04+01)

$= -27.5\ kJ\ mol^{-1}$ (04+01)

(v) Let T be the temperature at which the free energy change of dissociation of HA in gas phase become equal to the free energy change of dissociation of HA in aqueous phase.

$\Delta G_{gas} = \Delta G_{aq}$

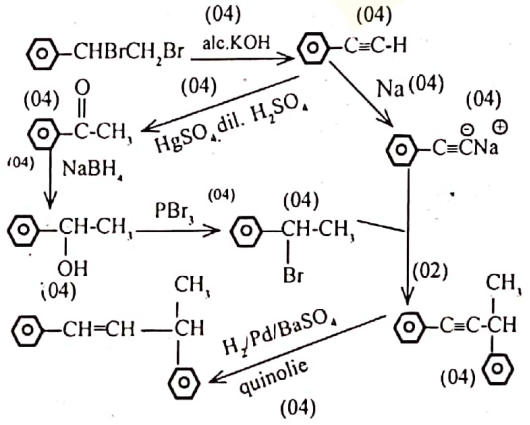
$T = \frac{\Delta H_5 - \Delta H_1}{\Delta S_5 - \Delta S_1}$

$T = \frac{(1151.0 - 1.0) kJ\ mol^{-1}}{(3.195 - 0.095) kJ\ mol^{-1}\ k^{-1}}$ (04+01)

$T = 370.9\ k$ **or** $97.96\ C^0$ (04+01)

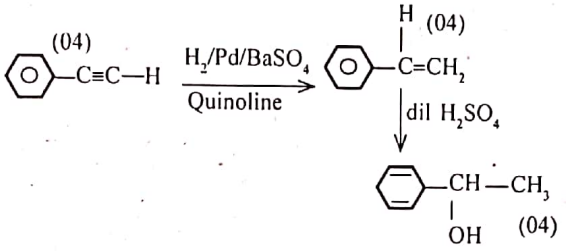
6(b) 100 Marks

7. (a)

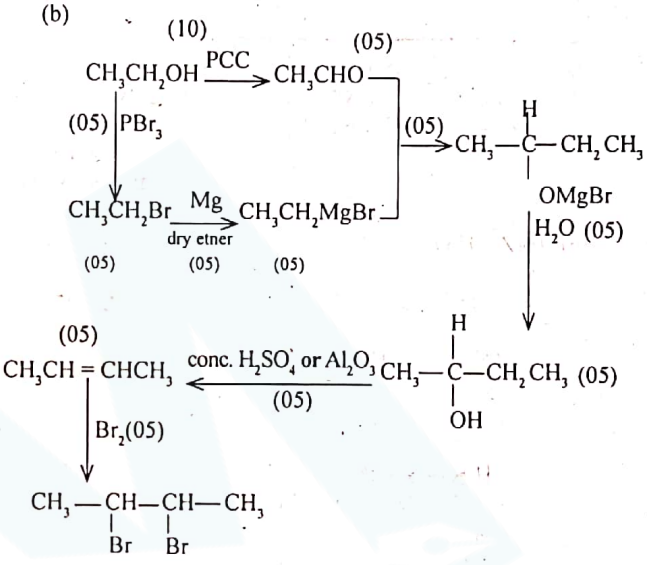


7(a) 50 Marks

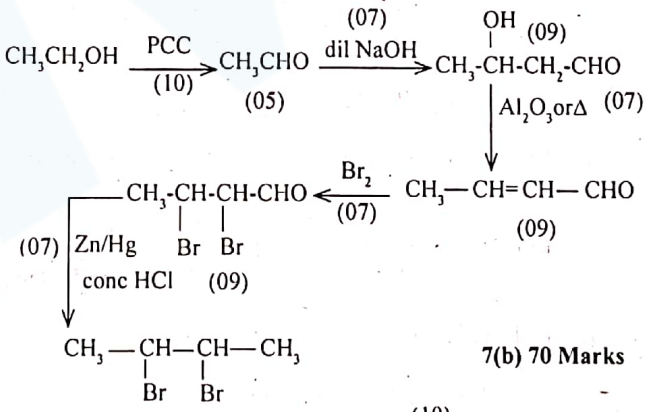
Alternative method for synthesis of Ph CH(OH)CH_3



(b)

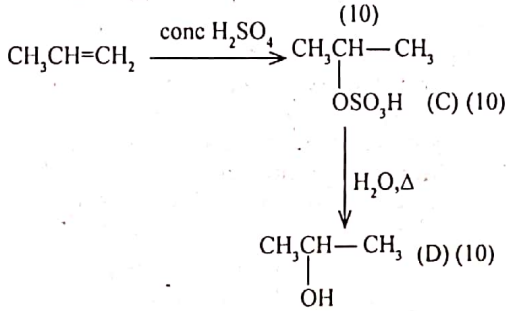


The following may be accepted for assigning marks based on the A/L syllabus content.

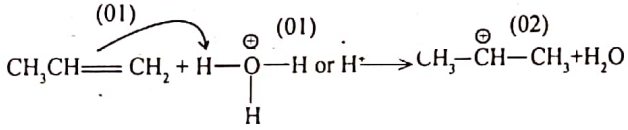


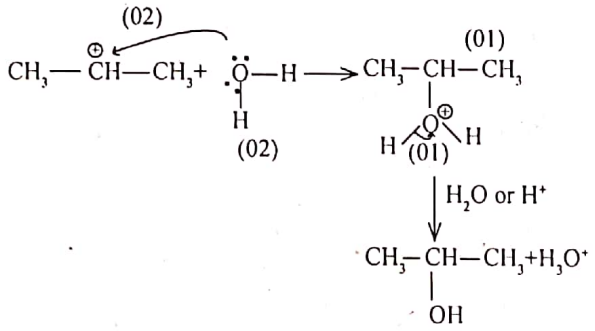
7(b) 70 Marks

(c)



$H_2O + H_2SO_4 \longrightarrow H_3O^+$





Statement Only,

The water in dilute H_2SO_4 can act as a nucleophile and react with the CH_3-$\overset{\oplus}{C}H$-CH_3 carbocation and form the alcohol. (04)

Note: If structure of carbocation is not given no marks for statement.

7(c) 30 Marks

PART C - ESSAY

8. (a) P = $NaNO_3$ Q = $NaNO_2$ R = O_2 S = NO_2
T = NaCl U = N_2 V = NH_3 W = Ca_3N_2
X = MgO Y = $Mg(OH)_2$

(05 x 10)

8(a) 50 Marks

(b) (i) Z = H_2O_2 (10)

(ii) $MnO_2 + 4H^+ + 2e \rightarrow Mn^{2+} + 2H_2O$ (03)

$H_2O_2 \rightarrow 2H^+ + O_2 + 2e$ (03)
or
$MnO_2 + H_2O_2 + 2H^+ \rightarrow Mn^{2+} + 2H_2O + O_2$ (08)

$H_2S \rightarrow S + 2H^+ + 2e$ (03)
$H_2O_2 + 2H^+ + 2e \rightarrow 2H_2O$ (03)
or
$H_2O_2 + H_2S \rightarrow S + 2H_2O$ (08)

$SO_2 + 2H_2O \rightarrow SO^{2-}_4 + 4H^+ + 2e$ (03)
$H_2O_2 + 2H^+ + 2e \rightarrow 2H_2O$ (03)
or
$H_2O_2 + SO_2 \rightarrow 2H^+ + SO^{2-}_4$ (or H_2SO_4) (08)
$H_2SO_4 + BaCl_2 \rightarrow BaSO_4 \downarrow + 2HCl$ (05)

(iii) As an antiseptic, bleaching agent, Oxidizing agent, fuel, reducing agent (03 + 03)

(iv) Hydrogen bonding (05)

8(b) 50 Marks

(c) (i) I. $2Cr^{3+} + 3\ S_2O^{2-}_8 + 7H_2O \rightarrow Cr_2O^{2-}_7 + 6SO^{2-}_4 + 14H^+$ (04)

$6Fe^{2+} + Cr_2O^{2-}_7 + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$ (04)

(ii) Let the thickness of the chromium layer be **Y cm** (01)

Area of the rectangular sample = 8.0 × 5.0
= 40.0 cm^2 (01 + 01)

Volume of chromium layer = 40.0 × y cm^3 (01 + 01)

Mass of chromium layer = 40.0 × y × 7.2 g (01 + 01)

Moles of chromium in the layer = $\frac{40.0 \times y \times 7.2}{52}$ (02)

Molar mass of $Fe(NH_4)_2(SO_4)_2.6H_2O$ = 392 g mol^{-1} (02)

∴ Therefore, moles of Ferrous (Fe^{2+}) = $\frac{3.10}{392}$ (02)

Moles of $K_2Cr_2O_7$ used to titrate excess Fe^{2+}
= $\frac{0.05}{1000} \times 8.5$ (03)

∴ Moles of excess Fe^{2+} = $6 \times \frac{0.05}{1000} \times 8.5$ (03)

Therefore, moles of Fe^{2+} reacted with $Cr_2O^{2-}_7$, formed as a result of dissolution of chromium layer in the sample

$= \left[\frac{3.10}{392}\right] - \left[6 \times \frac{0.05}{1000} \times 8.5\right]$ (03)

$= (7.91 \times 10^{-3}) - (2.60 \times 10^{-3})$
$= 5.31 \times 10^{-3}$ (03)

Therefore, moles of $Cr_2O^{2-}_7$, due to dissolution of chromium layer = $1/6 \times 5.31 \times 10^{-3}$ (03)

Therefore, moles of Cr^{3+} = $2 \times 1/6 \times 5.31 \times 10^{-3}$ (03)
= 1.77×10^{-3} (03)

$\frac{40.0 \times y \times 7.2}{52} = 1.77 \times 10^{-3}$ (03)

y = 3.2×10^{-4} (cm) (05)

Alternative Answer

Let the thickness of the chromium layer be y cm (01)

Molar mass of $Fe(NH_4)_2(SO_4)_2.6H_2O$ = 392 $gmol^{-1}$ (02)

Initial moles of Ferrous (Fe^{2+}) = $\frac{3.10}{392}$ (02)

Moles of $K_2Cr_2O_7$ used to titrate excess Fe^{2+} = $\frac{0.05}{1000} \times 8.5$ (03)

$Fe^{2+} : Cr_2O^{2-}_7 = 6:1$

Moles of excess (unreacted) Fe^{2+} = $6 \times \frac{0.05}{1000} \times 8.5$ (03)

Therefore, moles of Fe^{2+} reacted with $Cr_2O^{2-}_7$ formed as a result of dissolution of chromium

Layer in the sample $= \left[\frac{3.10}{392}\right] - \left[6 \times \frac{0.05}{1000} \times 8.5\right]$ (03)

$= (7.91 \times 10^{-3}) - (2.60 \times 10^{-3})$
$= 5.31 \times 10^{-3}$ (03)

Initial moles of $Cr_2O^{2-}_7$ due to dissolution of chromium layer = $1/6 \times 5.31 \times 10^{-3}$ (03)

Therefore, moles of Cr^{3+} = $2 \times 1/6 \times 5.31 \times 10^{-3}$ (03)
= 1.77×10^{-3} (03)

Mass of Cr^{3+} = $1.77 \times 10^{-3} \times 52$ g (03)

Therefore, volume of Cr^{3+} layer = $\frac{1.77 \times 10^{-3} \times 52}{7.2}$ cm^3 (03)

Y × 8.0 cm × 5.0 cm = $\frac{1.77 \times 10^{-3} \times 52}{7.2 \times 40}$ cm^3 (03)

Y = 3.2×10^{-4} (cm) (05)

8(c) 50 Marks

9. (a) (i) hematite - Fe_2O_3 **or** Magnetite - Fe_3O_4 (02 + 02)
Coke - C (02 + 02)

Limestone - $CaCO_3$ or dolomite - $CaCO_3.MgCO_3$ (02+02)

Note : If more than one ore is given, the correct answer (Fe_2O_3 or Fe_3O_4) must be written within the first two.

(ii) **Coke**

(1) Coke burns in air to give CO_2 (01) with Liberation of a large amount of heat (01) This helps to keep the temperature of the blast furnace very high (01) at the bottom (01)

$C + O_2 \rightarrow CO_2 + heat$ (01).

(2) The CO_2 formed reacts with C to give CO (01) which is the main reducing agent (01) in the conversion of iron oxide to iron.

$CO_2 + C \rightarrow 2CO$ (01)

(3) To reduce FeO directly by C (01)

$2\ FeO + C \rightarrow 2Fe + CO_2$ (02)

$CaCO_3$

This is used to remove impurities (01) such as sand/silicates (01), alumina (01) from the ore by slag formation (01).

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$ (02)

$CaO + SiO_2 \rightarrow CaSiO_3$ (slag) (02)

$CaO + Al_2O_3 \rightarrow Ca(AlO_2)_2$ (slag) (02)

Also accepted

$CaO + P_2O_5 \rightarrow Ca_3(PO_4)_2$

Slag is obtained in the molten state (01) and is less dense than the molten iron (01). Therefore, Slag floats on top of the iron (01) and prevents atmospheric oxidation (01), mainly due to the hot air blown at the bottom.

(iii) $3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$ —(1) (03)

$Fe_3O_4 + CO \rightarrow 3FeO + CO_2$ — (2) (03)

$FeO + CO \rightarrow Fe + CO_2$ — (3) (03)

$2FeO + C \rightarrow 2Fe + CO_2$ — (4) (02)

Note : Marks to be awarded only once

(iv) Pig iron (02)

Composition : Fe (01), 3-4% C (01) ; Si, P, S, Mn (any three) (01)

(v) (1) Reduce carbon content (02)

(2) Remove Si, Mn, P, as slag (02)

(3) Add alloying elements or adding Cr/Ni (02)

(4) Heat with air or O_2 or Blow hot air or O_2 to molten iron (02)

(vi) (iii) From part (iii), Add eq (1) + (2) x 2 + (3) x 6 or otherwise to give

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ (05)

To produce 2 moles of Fe, require 3moles of CO (01)

To produce 2x56 g of Fe require 3 x 28g of CO (01)

Therefore, to produce 2000 kg of Fe,

require $= \frac{3 \times 28 \times 2000}{2 \times 56}$ kg of CO

$= 1500$ kg (04)

(vii) CO_2, CO, N_2 (01+ 01+01)

predominant species : N_2 (02)

9(a) 75 Marks

(b) (i) I atmosphere - CO_2, CH_4, volatile hydrocarbons (other than CH_4), Carbon porticles, CO (02 + 02)

II lithosphere - fossil fuels, minerals containing carbonates, graphite, coke, diamond (02 + 02)

III hydrosphere -(dissolved) CO_2 or CO_2 (aq) or H_2CO_3, Carbonates, bicarbonates (02 + 02)

(ii)
- Photosynthesis (removes CO_2 from atmosphere)
- Respiration by plants and animals (all living organisms) (add CO_2 to atmosphere)
- Dissolution of CO_2 in water (removes CO_2 from atmosphere)
- Ruminant animals produce CH_4 (in their digestive systems due to fermentation by anaerobic bacteria)
- Natural combustion (eruption of volcanoes and natural fires) (gives out carbon species to atmosphere)
- Bacterial decomposition of organic matter (releases CO_2 & CH_4)
- Microorganisms can get the carbon species in dead plants & animals back into the atmosphere (Any five. Other valid answers are accepted) (04x05)

(iii)
- Burning of fossil fuels in large amounts release CO_2 and other hydrocarbons to the atmosphere.
- Wetland based agriculture (paddy cultivation) and livestock release CH_4 to the atmosphere.
- During synthesis of halogenated hydrocarbons, these can enter the atmosphere
- Deforestation

Any **three** Other valid answers are accepted (04×03)

(iv) global warming
Ozone layer depletion
Photochemical smog
any two (05×02)

(v) CO_2, CH_4, hydrocarbons, NO_2 (NO_x), halogenated hydrocarbons or CFC, HCFC, HFC
any three (03×03)

(vi) **global warming**
- Shifts in rainfall pattern
- Rise in mean sea level (melting of polar ice caps/ glaciers)
- Heavy snowfalls
- Frequent cyclones
- Desertification (Productive land into deserts)
- Droughts lasting long periods
- Frequent heat waves
- Extinction of species
- Epidemic diseases
- Increase in global temperatare
- Drying of frehwater reservoirs

(iv) **Ozone Layer Depletion**
- Skin cancer
- Cataract
- Respiratory diseases
- Heat strokes resulting in death

Photochemical smog
- Respiratory diseases
- Eye irritation
- Visibility problem

Note: Two from any **two** issues (03×02) + (03 × 02)

9(b) 75 Marks

10. (a) (i) I. $ClO^-(aq) + 2H^+ + Cl^-(aq) \rightarrow Cl_2(g) + H_2O$ (given)

$Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$ (02)

or

$ClO^- + 2H^+ + 2I^- \rightarrow I_2 + Cl^- + H_2O$ (06)

Alternative Answer

$ClO^-_{(aq)} + 2H^+ + 2I^- \rightarrow Cl^- + H_2O + I_2$ (02)

$2I^- \rightarrow I_2 + 2e$ (02)

or

$ClO^- + 2H^+ + 2I^- \rightarrow Cl^- + H_2O + I_2$ (06)

$I_2 + 2\,S_2O^{2-}_3 \rightarrow S_4O^{2-}_6 + 2I^-$ (02)

II. Moles of $S_2O^{2-}_3 = \frac{0.3 \times 19.0}{1000}$ (02)

Moles of $I_2 = 1/2 \times \frac{0.3 \times 19.0}{1000}$ (02)

Moles of $ClO^- = 1/2 \times \frac{0.3 \times 19.0}{1000}$

$= 2.85 \times 10^{-3}$ (02)

Moles of ClO^- in 250.0 cm^3

$= 2.85 \times 10^{-3} \times 10$ (02)

$= 2.85 \times 10^{-2}$ (02)

Therefore, moles of available $Cl_2 = 2.85 \times 10^{-2}$ (02)

Mass of available Cl_2 in 250.0 $cm^3 = 2.85 \times 10^{-2} \times 71$ g (02)

$$\% \text{ of available } Cl_2 = \frac{\text{mass of available } Cl_2 \text{ in } 250.0\ cm^3 \times 100}{\text{mass of bleaching solution}} \quad (03)$$

mass of bleaching solution $= 25.0 \times 1.0$ (02)

$= 30$ (g) (01)

Available $Cl_2 = 2.85 \times 10^{-2} \times 71 \times \frac{100\%}{30}$ (01)

$= 6.8\ \%$ (04)

(ii) I. $1S^2\,2S^2\,2P^6\,3S^2\,3P^6\,3d^6\,4S^2$ or $1S^2\,2S^2\,2P^6\,3S^2\,3P^6 4S^2 3d^6$ (05)

II. +2, +3 or +II, + III (05 + 05)

III. $K_4[Fe(CN)_6]$ or $[Fe(CN)_6]^{4-}\,4K^+$ (05)

(iv) Potassium hexacyanoferrate (II) (05)

or

Potassium hexacynidoferrate (II)

(v) $K_2[Fe(CN)_5(NO)]$ or $K_2[Fe(NO)(CN)_5]$ (05)

or

$[Fe(CN)_5(NO)]^{2-}\,2K^+$ or $[Fe(NO)(CN)_5]^{2-}\,2K^+$

(vi) entering group NO^+ (05)

leaving group CN^- (05)

10(a) 75 Marks

(b) (i) Amount of D in 1.0dm^3 of waste water

$= 0.001\ mol\ dm^{-3} \times 1.0\ dm^3$ (04 + 01)

$= 0.001$ mol (04 + 01)

Amount of electrons released when the amount of D is oxidized,

$= 0.001\ mol \times 2$

$= 0.002$ mol (04 + 01)

Amount of electricity (charge) needed,

$= 96500\ C\ mol^{-1} \times 0.002\ mol$ (04 + 01)

Time required for complete oxidation of D in 1.0 dm^3 of waste water

$= \frac{96500\ C\ mol^{-1} \times 0.002\ mol}{100 \times 10^{-3}\ C\ s^{-1}}$ (04 + 01)

$= 1.93 \times 10^3$ s **or**

32.16 min **or** 0.536h

(04 + 01)

(ii) At 25 ^0C

During the electrochemical process OH^- is Produced,

$[OH^-] = 0.001\ mol\ dm^{-3} \times 2$ (04 + 01)

$POH = -\log(0.002)$ (04 + 01)

$= 2.698$

$PH = 14.0 - 2.698$ (04 + 01)

$PH = 11.3$ (04 + 01)

(iii) When waste water is released continuously, current must be supplied to the cell continuously. (05)

Current needed to be supplied

$= 0.001 mol\ dm^{-3} \times 2 \times 96500\ C\ mol^{-1} \times 10.0\ dm^3\ s^{-1}$ (04 + 01) × 3

$= 1930\ C\ s^{-1}$ **or** 1930 A (04 + 01)

10 (b) 75 Marks