G.C.E.(A.L.) Support Seminar - 2015

Chemistry I

Two hours

Important :

* Answer all the questions.
* Select the **correct** or **most appropriate** response.

Universal gas constant, R = $8.314\,J\,K^{-1}\,mol^{-1}$
Avogadro constant, N_A = $6.022 \times 10^{23}\,mol^{-1}$
Planck constant, h = $6.624 \times 10^{-34}\,J\,s$
Velocity of light, c = $3 \times 10^{8}\,m\,s^{-1}$

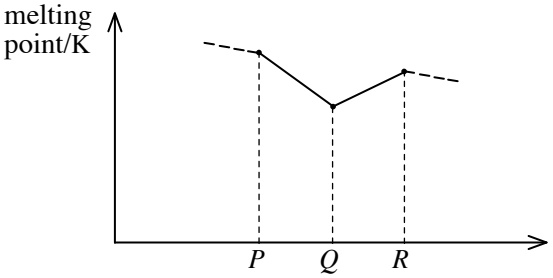
1. The set of quantum numbers, $[n = 2, l = 1, m_l = 0, m_s = +\frac{1}{2}]$ represents a

(1) 1*s* electron (2) 2*s* electron (3) 2*p* electron (4) 3*s* electron (5) 3*p* electron

2. *X* and *Y* are elements of the same period and they form molecules, XF_3 and YF_4. Which of the following elements can be *X* and *Y* ?

(1) S and Cl (2) O and N (3) B and N (4) N and O (5) Cl and S

3. *P*, *Q* and *R* are three consecutive elements of the first transition series. The variation of melting points of them are indicated in the diagram.



Which of the following can be *P*, *Q* and *R* respectively?

(1) Ti, V, Cr (2) V, Cr, Mn (3) Cr, Mn, Fe
(4) Mn, Fe, Co (5) Fe, Co, Ni

4. What is the correct IUPAC name of $(NH_4)_2[Co(CN)_2Cl_2(NO)_2]$?

(1) diammonium dichloridodicyanidodinitrosylcobalt(II)
(2) ammonium dichloridodicyanidodinitrosylcobaltate(II)
(3) diammine dicyanidodichloridonitrosylcobaltate(III)
(4) ammonium dichloridodicyanidodinitrosylcobaltate(III)
(5) ammonium dicyanidodichloridodinitrocobaltate(III)

5. The correct ascending order of electronegativity of carbon atom of the given compounds is

(1) HCHO < HCOOH < HCN < CO_2 (2) HCOOH < HCHO < CO_2 < HCN
(3) HCN < HCHO < HCOOH < CO_2 (4) CO_2 < HCN < HCHO < HCOOH .
(5) HCHO < HCN < HCOOH < CO_2

6. The concentration of Cl^- ions in an equimolar solution containing $MgCl_2$ and $CaCl_2$ is 142 ppm. What is the composition of Mg^{2+} ions of the solution in ppm? (Mg = 24, Ca = 40, Cl = 35.5)

(1) 71 ppm (2) 142 ppm (3) 24 ppm (4) 48 ppm (5) 96 ppm

7. The standard enthalpy of solution of $MgCl_2(s)$ is $+23\,kJ\,mol^{-1}$ while the standard enthalpies of hydration of $Mg^{2+}(g)$ and $Cl^-(g)$ ions are $-1891\,kJ\,mol^{-1}$ and $-381\,kJ\,mol^{-1}$ respectively. What is the standard lattice enthalpy of $MgCl_2(s)$ in $kJ\,mol^{-1}$?

(1) −2676 (2) −2630 (3) −2295 (4) +2295 (5) +2630

8. A sample of an alloy containing Mg and Al with the molar ratio 1 : 2 is reacted with 50.00 cm^3 of 0.4 $mol\,dm^{-3}$ hydrochloric acid. After the ceasing of evolution of gas, 60.00 cm^3 of 0.20 $mol\,dm^{-3}$ sodium hydroxide solution were required to neutralise the remaing solution. What was the mass of Al in the initial sample? (Al = 27)

(1) 0.027 g (2) 0.054 g (3) 0.240 g (4) 0.510 g (5) 0.540 g

9. What is the temperature at which the mean square velocity of SO_2 gas equals the mean square velocity of O_2 at 27 °C ? (assume the ideal behaviour of gases; S = 32, O = 16)

(1) 600 °C (2) 327 K (3) 300 K (4) 327 °C (5) 300 °C

[see page two

10. In basic medium, M^{2+} ions get oxidised to MO^{n+} by MnO_4^-. In the presence of NaOH, 40.00 cm^3 of 1.25 mol dm^{-3} $KMnO_4$ solution were required for complete reaction with 25.00 cm^3 of 1.20 mol dm^{-3} M^{2+} solution. What is the value of *n*?

(1) 1 (2) 2 (3) 3 (4) 4 (5) 5

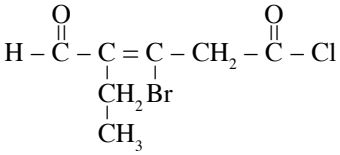
11. Which of the following compounds gives the highest concentration of H_3O^+ when 1.0 mol of each compound is dissolved in 10 dm^3 of water ?

(1) HCl (2) CH_3COOH (3) PCl_5 (4) NH_4Cl (5) H_2SO_4

12. When acidified $KMnO_4$ is added to the solution formed by dissolving an inorganic compound *X* in water, the solution turns yellowish brown while evolving a colourless gas. Which of the following compounds can be *X*?

(1) $Fe(NO_3)_2$ (2) FeC_2O_4 (3) $Fe(NO_2)_2$ (4) $FeCl_3$ (5) $Fe(NO_3)_3$

13. What is the correct IUPAC name for the following compound?



(1) 3 - bromo - 2 - ethyl - 5 - oxo - 2 - pentenal
(2) 3 - bromo - 2 - ethyl - 4 - chlorocarbonyl - 2 - pentenal
(3) 3 - bromo - 4 - formyl - 3 - hexenoylchloride
(4) 3 - bromo - 4 - ethyl - 5 - oxopent - 3 - enoyl chloride
(5) 3 - bromo - 4 - formyl - 3 - hexenoyl chloride

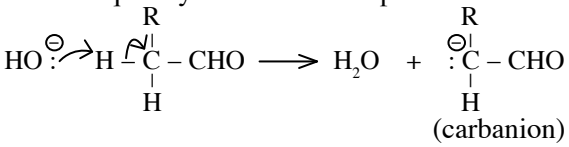
14. When H_2S gas was passed through an aqueous solution containing two cations after acidifying with diluted HCl, a yellow precipitate was formed. Dilute HNO_3 acid was then added to the filtrate and boiled until the total volume became half. When NH_4Cl crystals and concentrated NH_4OH were added a white precipitate was formed. Which of the following cations would have been present in the initial solution?

(1) Sn^{2+}, Sr^{2+} (2) Sn^{4+}, Sn^{2+} (3) Cd^{2+}, Fe^{2+} (4) Sb^{3+}, Ca^{2+} (5) As^{3+}, Al^{3+}

15. The pressure of a gaseous mixture containing NH_3 and N_2H_4 gases at 300 K is 5.0×10^4 Pa. When this mixture is heated to 1200 K without changing the volume, it is completely decomposed only to N_2 and H_2 gases. Then the total pressure of the system is 4.5×10^5 Pa. The mass of nitrogen gas formed by the reaction is 0.28 g. What is the molar ratio between NH_3 and N_2H_4 in the initial mixture?

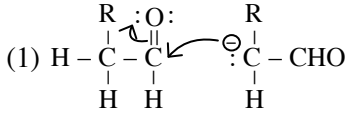
(1) 1 : 1 (2) 1 : 2 (3) 3 : 1 (4) 2 : 3 (5) 3 : 2

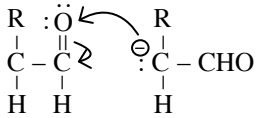
16. Carbonyl compounds with α - hydrogen undergo aldol condensation in the presence of dilute alkaline solutions. It has been shown that this reaction is initiated by the carbanion formed in the presence of hydroxide ions which subsequently acts as a nucleophile.

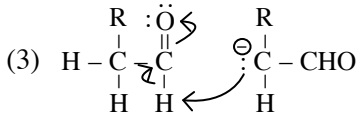


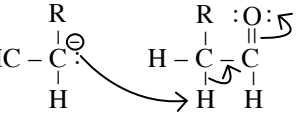
(carbanion)

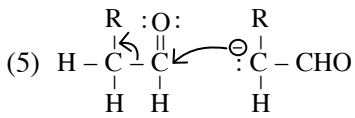
Which of the following best explains the next step of this reaction which leads to condensation?

(1) 

(2) 

(3) 

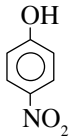
(4) 

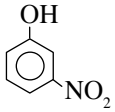
(5) 

[see page three

17. Which of the following answers gives the correct ascending order of acidic nature of the given compounds?


(*A*)


(*B*)


(*C*)


(*D*)

(1) $A < C < D < B$ (2) $C < B < D < A$ (3) $A < C < B < D$ (4) $A < B < C < D$ (5) $C < B < A < D$

18. Of *A*, *B*, *C* and *D* what are the reactions that truely happen?

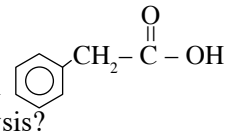
(*A*) $CH_3COCl \xrightarrow{Mg/dry\ ether} CH_3 - \overset{O}{\overset{\|}{C}} - MgCl$

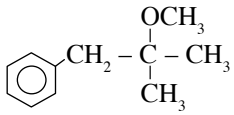
(*B*) $CH_3C \equiv CNa \xrightarrow{HCHO} H - \underset{H}{\overset{ONa}{\overset{|}{\underset{|}{C}}}} - C \equiv C - CH_3$

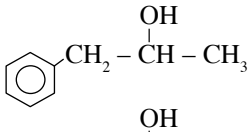
(*C*) $CH_3CH_2Cl \xrightarrow{CH_3ONa} CH_2 = CH_2 + CH_3CH_2 - OCH_3$

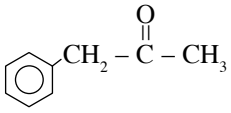
(*D*) $CH_3CONHC_6H_5 \xrightarrow[\Delta]{NaOH} CH_3NH_2 + C_6H_5COO^-Na^+$

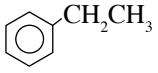
(1) *A* and *B* only. (2) *B* and *C* only. (3) *A*, *B* and *C* only.
(4) *B*, *C* and *D* only. (5) All *A*, *B*, *C* and *D*

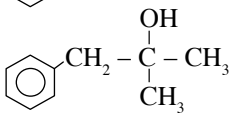
19. Which of the following compounds is formed as the product when the compound  is reacted with PCl_5 and then reacted with excess CH_3MgBr followed by hydrolysis?

(1) 

(2) 

(3) 

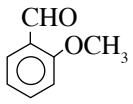
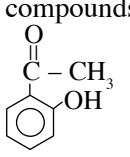
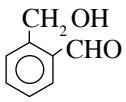
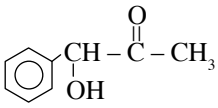
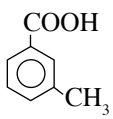
(4) 

(5) 

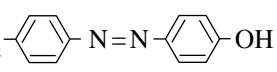
20. The organic compound, *X* gave the following observations.

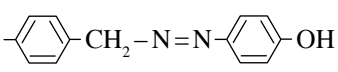
(*A*) did not give silver mirror with the Tollen's reagent
(*B*) reacted with metallic Na liberating a gas
(*C*) did not react with aqueous Na_2CO_3 solution
(*D*) reacted with pyridinium chlorochromate (PCC)

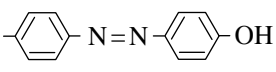
Which of the following compounds could be *X*?

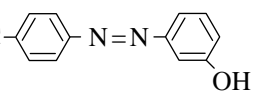
(1)  (2)  (3)  (4)  (5) 

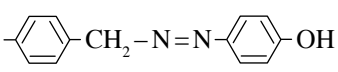
21. The compound $H_2N - H_2C$  NH_2 is treated with $NaNO_2$/dil.HCl at 0 - 5°C and the resulting solution is added to a solution of phenol in aqueous NaOH at 0 - 5°C. The major organic product expected is,

(1) $HO - CH_2$ 

(2) HO 

(3) $H_2N - H_2C$ 

(4) $HO - H_2C$ 

(5) H_2N 

[see page four

22. Which of the following reactions gives a product having two asymmetric carbon atoms?

(1) $CH_2 = CHCH_2CH_2Cl \xrightarrow{\text{dil. } H_2SO_4}$

(2) $CH_3-\overset{O}{\overset{\|}{C}}-CH_2-\overset{O}{\overset{\|}{C}}-OH \xrightarrow[\text{ii. } H^+/H_2O]{\text{i. } LiAlH_4}$

(3) $CH_3CH_2-\overset{O}{\overset{\|}{C}}-H \xrightarrow{\text{dil. NaOH}}$

(4) $CH_3CH_2-\overset{CH_3}{\overset{|}{C}}(CH_2Cl)-Cl \xrightarrow[\text{ii. } H_2O]{\text{i. Mg/dry ether}}$

(5) $CH_3CH_2-\underset{O}{\overset{\|}{C}}-Cl \xrightarrow{CH_3-\overset{CH_3}{\overset{|}{C}}H-NH_2}$

23. The reaction represented by the balanced equation, $A + B \longrightarrow Y$, with rate constant k, is first order with respect to A and zeroth order with respect to B. When n mol of A and n mol of B are reacted in a solution of volume V, it is found that x mol of Y is formed in time t. If the rate of the reaction at time t is R, the value of x is,

(1) $n-\frac{R}{k}$ (2) $n-\frac{RV}{k}$ (3) $\frac{n}{V}-Rk$ (4) $n-\frac{Rk}{V}$ (5) $n-\frac{\sqrt{RV}}{\sqrt{k}}$

24. What is the mole fraction of A in the vapour which is in equilibrium with the ideal equimolar solution AB formed by A and B?
(The vapour pressure of pure A is twice that of pure B at that temperature.)

(1) $\frac{1}{4}$ (2) $\frac{1}{3}$ (3) $\frac{2}{5}$ (4) $\frac{1}{2}$ (5) $\frac{2}{3}$

25. At 25°C, a 0.1 mol dm^{-3} solution of a weak monobasic acid was diluted 100 times with water. What is the pH of the resulting solution? (Ka of the acid at 25°C is 1×10^{-5} mol dm^{-3})

(1) 1 (2) 3 (3) 4 (4) 5 (5) 7

26. What is the maximum amount of moles of AgCl that dissolves in 500 cm^3 of a 0.05 mol dm^{-3} $CaCl_2$ solution? [$K_{sp}(AgCl) = 1\times10^{-10}$ mol^2 dm^{-6}]

(1) 0.5×10^{-10} mol (2) 1×10^{-10} mol (3) 5×10^{-10} mol
(4) 1×10^{-9} mol (5) 5×10^{-8} mol

27. $N_2O_4(g)$ dissociates according to the following equation.

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

When 1.0 mol of $N_2O_4(g)$ is placed in a closed vessel to reach equilibrium at a certain temperature, what is the value of the degree of dissociation α, if the total pressure is P and the equilibrium constant is K_P?

(1) $\alpha = \frac{K_P}{K_P + 4P}$ (2) $\alpha = \left(\frac{K_P}{4+K_P}\right)^{\frac{1}{2}}$ (3) $\alpha = \left(\frac{1}{1+4P/K_P}\right)^{\frac{1}{2}}$

(4) $\alpha = \frac{K_P/P}{4+K_P/P}$ (5) $\alpha = \left(\frac{K_P/P}{4-K_P/P}\right)^{\frac{1}{2}}$

28. Solid A partially dissociates according to the following equation at the temperatures above 350 K.

$A(s) \rightleftharpoons 2B(g) + C(g)$

When a certain amount of solid A is placed in a closed vessel and allowed to reach equilibrium at 400 K, K_P of the system is 3.2×10^{13} Pa^3. What is the partial pressure of B(g) at the equilibrium?

(1) 1.6×10^3 Pa (2) 1.6×10^4 Pa (3) 2.0×10^4 Pa (4) 4.0×10^4 Pa (5) 8.0×10^4 Pa

29. The same current was passed through the aqueous solutions of $NiSO_4$, $AgNO_3$ and $Cr(NO_3)_3$ of same concentration for a certain period of time. What is the molar ratio of the metals Ni, Ag and Cr deposited on the cathode? (Assume only the metal cations are reduced.)

(1) 2 : 3 : 3 (2) 3 : 6 : 2 (3) 3 : 2 : 6 (4) 2 : 1 : 3 (5) 29 : 108 : 26

[see page five

30. Consider the following equilibrium.

$A(g) + B(g) \rightleftharpoons 3C(g)$; $\Delta H < 0$

Which of the following change causes an increase in the amount of product C?

(1) increasing temperature at constant pressure
(2) increasing pressure at constant temperature
(3) decreasing volume at constant temperature
(4) introducing an inert gas to the system at constant pressure
(5) introducing an inert gas to the system at constant volume

- For each of the question **31** to **40**, four responses (a), (b), (c) and (d) are given of which one or more 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/are correct.

Summary of above instructions

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

31. Which of the following statement/s is/are true about an atom with sp hybridisation?

(a) always there are two VSEPR pairs
(b) can form a triple bond
(c) always two sigma (σ) bonds should be formed
(d) always at least one π bond should be formed

32. For which of the following reaction/s ΔH, ΔS and ΔG can be negative?

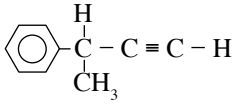
(a) $Ba(OH)_2(aq) + H_2SO_4(aq) \longrightarrow BaSO_4(s) + 2H_2O(l)$ (b) $4Na(s) + O_2(g) \longrightarrow 2Na_2O(s)$
(c) $6CO_2(g) + 6H_2O(g) \longrightarrow C_6H_{12}O_6(s) + 6O_2(g)$ (d) $2H_2O(l) \longrightarrow 2H_2(g) + O_2(g)$

33. Which of the following statement/s is/are true about the chemistry of NH_3?

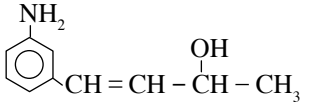
(a) When NH_3 acts as an oxidising agent, always hydrogen gets reduced.
(b) When NH_3 reacts with metals, always amide (NH_2^-) of the metal is formed.
(c) NH_3 is formed when solid NH_4Cl is added to molten $NaNH_2$.
(d) When NH_3 reacts with excess chlorine, H_2 is formed.

34. When an aqueous solution of ammonia is added to an aqueous solution of cations of metal *M*, a green precipitate is formed. When H_2O_2 is added to this precipitate, a sharp colour change is observed. Which of the following cation/s would be *M*?

(a) Mn^{2+} (b) Fe^{2+} (c) Cr^{3+} (d) Ni^{2+}

35. The compound, 

(a) exists as opitical isomers.
(b) exists as geometrical isomers.
(c) forms a white crystalline solid by the reaction with acidified potassium permanganate.
(d) does not react with ammoniacal silver nitrate.

36. Which of the following statement/s is/are true about the compound, 

(a) It reacts with HNO_2 giving N_2 gas.
(b) The product formed when it reacts with anhydrous Al_2O_3, does not exhibit stereoisomerism.
(c) It has only two carbon atoms with sp^2 hybridisation.
(d) It reacts with both PBr_3 and Br_2.

[see page six

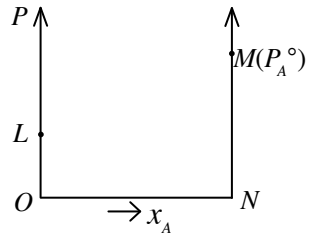
37. Which of the following statement/s is/are true about the effect of a catalyst for a certain chemical reaction?

(a) reducing the activation energy
(b) increasing the fraction of effective collisions
(c) increasing the negative value of ΔG
(d) changing the mechanism

38. Which of the following reactions release(s) chlorine gas as a product?

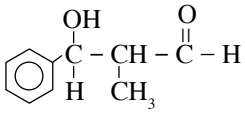
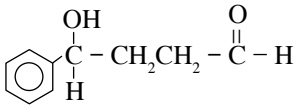
(a) $Cl^-(aq) + I_2(aq) \longrightarrow$
(b) $Cl^-(s) + \text{conc. } H_2SO_4(aq) \longrightarrow$
(c) $MnO_2(s) + H^+(aq) + Cl^-(aq) \longrightarrow$
(d) $OCl^-(aq) + Cl^-(aq) + H^+(aq) \longrightarrow$

39. Which of the following statements/s is/are correct about the points indicated in a composition - vapour pressure graph of an ideal binary solution formed by *A* and *B* liquids. ($P_A^\circ > P_B^\circ$ and x_A is the mole fraction of *A* in liquid phase.)



(a) Straight line *OM* indicates the partial pressure of *A*.
(b) Saturated vapour pressure of any solution containing *A* and *B* is lower than P_A° at the relevant temperature.
(c) At constant temperature, total vapour pressure lies on the straight line between *L* and *M*.
(d) The total vapour pressure in the vapour phase does not linearly vary with the mole fraction of *A* in the liquid phase.

40. Which of the following product/s is/are formed by the reaction between dilute NaOH and a mixture of benzaldehyde and propanal?

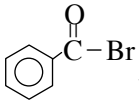
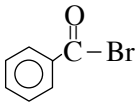
(a) 
(b) $CH_3CH_2-\underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}}-CH_2CH_2-\overset{\overset{O}{||}}{C}-H$
(c) 
(d) $CH_3CH_2-\overset{\overset{OH}{|}}{CH}-\overset{\overset{CH_3}{|}}{CH}-\overset{\overset{O}{||}}{C}-H$

- In questions number **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 given for each of the questions 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** explain the first statement correctly.
(3)	True	False.
(4)	False	True.
(5)	False	False.

	First statement	Second statement
41.	Radius of the gaseous K^+ ion is greater than the radius of the gaseous Na atom.	Effective nuclear charge of Na atom is higher than that of K^+ ion.
42.	Same energy is released when one mole of aqueous $Ba(OH)_2$ is completely neutralised by H_2SO_4 acid and two moles of aqueous KOH are completely neutralised by H_2SO_4 acid under same conditions.	When a strong acid is neutralised by a strong base the reaction, $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$ occurs.
43.	Solid AgI does not dissolve in concentrated ammonia solution.	The equilibrium constant of $AgI(s) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq) + I^-(aq)$ is very small.
44.	An aqueous sodium hydroxide solution as well as an aqueous ammonia solution are suitable to distinguish Al^{3+} and Zn^{2+} ions.	Al and Zn are amphoteric metals and their ions form complex compounds.

[see page seven

	First statement	Second statement
45.	When chlorine gas is bubbled after adding the liquid CCl_4 to an aqueous solution of the compund , a brown oily globe is formed.	Br atom in  is covalently bound.
46.	The electromotive force of a cell increases when the distance between the two electrodes is reduced.	Resistance of the cell is decreased when the distance between the two electrodes is reduced.
47.	When an aqueous solution of Na_2SO_4 solution is electrolysed using inert electrodes in the presence of phenolphthalein indicator, a pink colour appears near the anode.	Anions are attracted towards the anode during electrolysis.
48.	Of the oxides of nitrogen (NO_x) in the exhaust fumes of jet engines, NO and NO_2 greately harm the ozone layer.	NO and NO_2 give rise to free radicals.
49.	Teflon is not a thermosetting polymer.	Teflon is an addition polymer.
50.	A solution formed by mixing $CH_3-\overset{\overset{O}{\|}}{C}-OH$ and $C_2H_5O^-Na^+$ in the molar ratio of 2 : 1, exhibits buffer properties.	A buffer solution can be made by mixing a weak acid and a strong base.

***

G.C.E.(A.L.) Support Seminar - 2015

Chemistry II

Three hours

Important :

(i) Answer **all** the questions in part **A**.

(ii) Answer **four** questions selecting **two** questions from part **B** and **two** questions from part **C**.

Universal gas constant, $R = 8.314\,J\,K^{-1}\,mol^{-1}$ Planck constant, $h = 6.624 \times 10^{-34}\,J\,s$

Avogadro constant, $N_A = 6.022 \times 10^{23}\,mol^{-1}$ Velocity of light, $c = 3 \times 10^{8}\,m\,s^{-1}$

PART A - STRUCTURED ESSAY

Answer all **four** questions. Each question carries **10 marks.**

1. (*a*) Arrange the property given in parantheses in ascending order in each of the following.

(i) N_2H_4, NH_2^-, NH_2OH (oxidation number of the nitrogen atom)

..... < ..... < .....

(ii) H_2O_2, O_2, O_3 (O − O bond length)

..... < ..... < .....

(iii) SF_2, SF_4, SF_6 (bond energy of S – F bond)

..... < ..... < .....

(iv) Na, Zn, V (melting point)

..... < ..... < .....

(v) $Mg(OH)_2$, $Ba(OH)_2$, $Al(OH)_3$ (decomposition temperature)

..... < ..... < ..... (3.0 marks)

(*b*) Skeleton of the hyponitrate ion ($N_2O_3^{2-}$) is given below.

$$\overset{1}{O}-\overset{2}{O}-\overset{3}{N}-\overset{4}{N}-\overset{5}{O}$$

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

(ii) Draw resonance structures for this ion.

Answer questions from (iii) - (v) on the basis of the structure drawn in part (i) above.

(iii) State electron pair geometry arround the atoms O^2 and N^3.

O^2 - N^3 -

(iv) Which orbitals overlap to form the $N^4 - O^5$ bond?

N^4 - O^5 -

[see page two

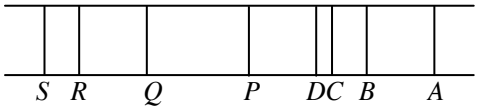
(v) Sketch the shape of the Lewis structure drawn in (i) above, indicating the approximate values of the bond angles.

(3.5 marks)

(*c*) The following table gives the energy of an electron when it exists in the principal energy level of a hydrogen atom. (The energy ralues are assigned negative sign in accordance with convention that the energy of an electron at an infinite energy level from the neucleus is zero.)

Principal energy level (n)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Energy of the electron / kJ mol^{-1}	–1311	–327	–145	–80	–52	–36	–24

Two series of lines of the emission spectrum of hydrogen are shown below.



Line *D* is violet in colour.

(i) Write the name of the series to which lines *P*, *Q*, *R*, *S* belong.

.....

(ii) What are the energies in kJ mol^{-1} of the two principal energy levels relevant to line *D*?

.....

.....

.....

(iii) What is the energy of one mole of photon of the radiation relevant to the line *D*?

.....

.....

.....

(iv) What is the frequency of the radiation relevant to the violet line?

.....

.....

.....

.....

.....

.....

(v) What is the first ionization energy of a hydrogen atom?

.....

.....

.....

(3.5 marks)

2. (*a*) This part is based on three gaseous hydrides, NH_3, H_2S and HI of three p-block elements.

(i) State which gas or gases could be identified by the tests given below. If any gas could not be identified write "none".

(I) Holding a wet red litmus paper .....

(II) Bubbling through an aqueous copper sulphate solution .....

(III) Holding a filter paper dipped in an acidified potassium dichromate solution .....

[see page three

(ii) Write balanced chemical equation, choosing one gas from the above which reacts with the substances given below.

(I) Sodium metal .....

(II) Chlorine water .....

(III) Sulphur dioxide gas .....

(iii) Write the formula of the product formed by the reaction between NH_3 and HI and write the types of chemical bonds present in the product.

.....

.....

.....

.....

(iv) Which hydrides given in 2(*a*) above, have the following intermolecular forces?

(I) Hydrogen bonds .....

(II) Dispersion forces (London forces) .....

(v) A certain salt when heated decomposes giving NH_3 and H_2S as the only products. Write the chemical formula and the name of the salt.

.....

.....

(6.2 marks)

(*b*) Zinc is an element in the 3d series.

(i) Write the electronic configurations of the zinc atom in the ground state and the Zn^{2+} ion.

Zn atom .....

Zn^{2+} ion .....

(ii) Zinc has the lowest melting point among the elements in the 3d series. Explain this fact in the light of the above electronic configurations.

.....

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(iii) A dilute aqueous solution contains both Zn^{2+} and Cu^{2+} ions of equal concentration. State what can be observed when two parts of this solution were treated separately as follows.

(I) Passing hydrogen sulphide gas after acidifying with hydrochloric acid.

.....

(II) Adding excess aqueous ammonia solution.

.....

(iv) Zinc ions exist as $[Zn(H_2O)_6]^{2+}$ in aqueous solution.

(I) Write the IUPAC name of the above ion.

.....

(II) What is the shape around the central zinc atom of the above ion?

.....

[see page four

(v) Nitric acid of certain concentration reacts with zinc to give zinc nitrate, hydrazine (N_2H_4) and water. Write the balanced chemical equation for this reaction.

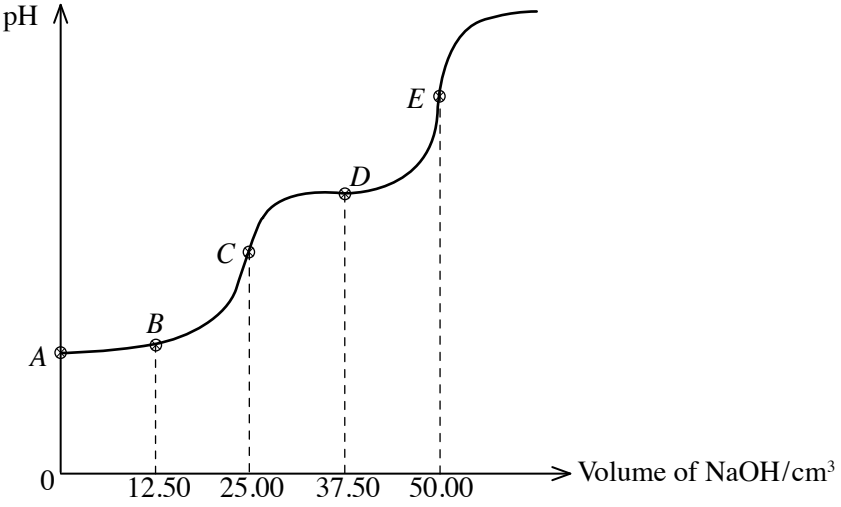
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(3.8 marks)

3. (*a*) H_2A is a weak dibasic acid. When 25.00 cm^3 of a 0.1 mol dm^{-3} aqueous H_2A solution is titrated with 0.1 mol dm^{-3} of aqueous NaOH solution, the variation of pH of the medium with the volume of the NaOH solution is shown in the graph given below.



(i) Write the chemical reaction for the first dissociation of H_2A and write an expression for the dissociation contant, K_{a_1}.

.....

.....

.....

.....

(ii) Of *A*, *B*, *C* and *D*, which point corresponds to the pH of the solution in the flask during the above titration when $[H_2A] = [HA^-]$?

.....

(iii) If the pH value relavant to the above point in (ii) is 3.0, calculate the value of K_{a_1}.

.....

.....

.....

.....

(iv) What is the point in the above graph relating to the stage when all the H_2A is converted to HA^-? Calculate the pH value relevant to this point (The second dissociation constant of H_2A, $K_{a_2} = 5.0 \times 10^{-8}$ mol dm^{-3}).

.....

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[see page five

(v) Which point in the above graph represents the pH at the stage when all the H_2A is converted to A^{2-} during the titration?

.....

(vi) Which point in the graph represents the stage at which the solution in the flask shows the buffer action best during the titration? Explain the buffer action of this solution by writing the relevant equations.

.....

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(7.0 marks)

(*b*) (i) Define the critical temperature.

.....

.....

(ii) Arrange, He, NH_3 and CO_2 according to ascending order of their critical temperatures.

..... < ..... < .....

(iii) Sketch approximately below how the compressibility factor of an ideal gas, helium gas and ammonia varies with pressure. Label your graphs.

(iv) Briefly explain the relationship between the compressibility factor of a real gas and the critical temperature.

.....

.....

.....

(3.0 marks)

[see page six

4. (*a*) *A*, *B*, *C* and *D* are four optically inactive isomers of molecular formula $C_5H_{12}O$. *A* gives an instant turbidity with anhydrous zinc chloride and concentrated hydrochloric acid. But *B*, *C* and *D* do not give such an observation. In the presence of PCC, *B*, *C* and *D* give products *E*, *F* and *G* respectively which respond to Fehling solution. In the presence of dilute sodium hydroxide, *E* and *F* give condensation products. *G* does not give such a product.

(i) Draw the structures of *A* and *D* in the boxes below.

A	*D*

(ii) Draw the possible structures, for *B* and *C* in the boxes given below.

(iii) *B* and *C* were first dehydrated using concentrated H_2SO_4, followed by the reaction with hydrogen bromide. Afterwards the products were reacted with alcoholic potassium hydroxide. *B* forms a product *H* which shows stereoisomerism. *C* does not give such a product.
Draw the structure of *B* in the box given below.

B

(iv) Draw the structure of *H* formed by *B* in (iii) above. (Showing three dimensional geometry is not required.)

H

(v) Which isomerism is shown by *H*?

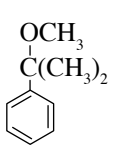
.....

(vi) Write the IUPAC name of *H*.

.....

(3.6 marks)

(*b*) $CH_3 - C \equiv C - H \xrightarrow[\text{reaction - 1}]{a} Q \xrightarrow[\text{reaction - 2}]{b} R \xrightarrow[\text{reaction - 3}]{c} S \xrightarrow[\text{reaction - 4}]{PBr_3} T$



$\xleftarrow[\text{reaction - 5}]{d}$

(i) Draw the structures of *Q*, *R*, *S* and *T* in the boxes given below.

Q	*R*

[see page seven

S	*T*

(ii) Indicate the reagents, *a*, *b*, *c* and *d*.

a - .....

b - .....

c - .....

d - .....

(iii) Classify each of the reactions in the above sequence as nucleophilic addition (A_N), electrophilic addition (A_E), nucleophilic substitution (S_N), electrophilic substitution (S_E) or other (*O*) by writing A_N, A_E, S_N, S_E or *O* and write the reactive species of each reaction in the following table as appropriate.

Reaction	Type of reaction	Active species
1		
2		
3		
4		
5		

(iv) Write the mechanism of reaction - 5.

(v) Draw the structure of another product that could be formed during reaction - 5 except the one given in (*b*).

(vi) In what manner does the reagent act during the reaction (v) above?

.....

(6.4 marks)

**

[see page eight

PART B - ESSAY

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

5. (*a*) (i) What is meant by "an ideal solution"?

(ii) Consider an ideal binary solution of *A* and *B* in equilibrium with its vapour in a closed system at constant temperature. Write all dynamic equilibria existing in the system.

(iii) Write rate expressions for the forward and backward reactions of the dynamic equilibrium brought about with the participation of *A*. (Define the terms used.)

(iv) Derive thereof the expression, $P_A = P_A^\circ . x_A$

where P_A = partial vapour pressure of *A*

P_A° = saturated vapour pressure of *A*

x_A = mole fraction of *A* in liquid phase

(3.0 marks)

(*b*) Volume V (V = 0.8314 dm^3) of each of the liquids *A* and *B* were added to an evacuated vessel of volume 100.8 V and allowed to reach the equilibrium. At 300 K, the total pressure of the system was found to be 3.00×10^5 Pa. At 300 K, the molar volumes of liquids *A* and *B* are 8.314×10^{-2} dm^3 mol^{-1} and 4.157×10^{-2} dm^3 mol^{-1} respectively. The solution of *A* and *B* behave ideally.

(i) Calculate separately the amounts of moles of *A* and *B* mixed.

(ii) Calculate separately the partial vapour pressures of *A* and *B* if the mole fraction of *A* in the vapour phase was 0.2.

(iii) Calculate separately the amounts of moles of *A* and *B* in the vapour phase assuming the volume of the vapour phase is 100 V.

(iv) Calculate separately the saturated vapour pressures of *A* and *B* at 300 K.

(v) The temperature of the above system was increased so that the liquids *A* and *B* completely vapourised. Then, only the gas *A* partially dissociated as $A(g) \rightleftharpoons 2C(g)$. When the system attained equilibrium at 403.2 K, the total pressure was 1.4×10^6 Pa.

(I) Calculate the partial pressures of each component at 403.2 K.

(II) Calculate equilibrium constant K_P for the equilibrium in (v) above at 403.2 K.

(7.0 marks)

(*c*) A sample of water is polluted due to mixing of a weedicide, *X*. You are provided with 150 cm^3 of diethyl ether for an experiment planned to remove *X* from 200 cm^3 of a polluted water sample. It is expected to do three succesive extractions by using 50 cm^3 of ether for each extraction. The distribution coefficient of *X* between ether and water at the relevant temperature is 16. (*X* is more soluble in ether than in water.)

(i) Write the equilibrium relevant to the distribution of *X* between water and ether and write an expression for K_D.

(ii) Express the amount of *X* remaining in water after the first extraction as a fraction of the initial amount.

(iii) Indicate as a percentage, the amount of *X* extracted into ether after three successive extractions.

(iv) Write two assumptions made in the above calculation.

(5.0 marks)

6. (*a*) (i) $CO(g)$ and $H_2(g)$ can be produced by the reaction between $CH_4(g)$ and $CO_2(g)$ in the presence of sunlight and a catalyst *A*. The standard enthalpy change for this reaction is *x* kJ mol^{-1}.
Above products can also be formed by reacting graphite with water vapour and the relevant enthalpy change is -125 kJ mol^{-1}.

Standard enthalpy of formation of $CO_2(g)$ is -394 kJ mol^{-1}

Standard enthalpy of combustion of $CH_4(g)$ is -800 kJ mol^{-1}

(I) Write balanced chemical equations for the above chemical reactions.

(II) Calculate the value of *x*.

(3.0 marks)

[see page nine

(*b*) Consider the following data relating to an experiment carried out for studying the rate of the reaction, $X + 2Y + Z \longrightarrow$ products; $\Delta H > 0$.
It was found that when 50 cm^3 of a 2.0 mol dm^{-3} solution of *X*, 100 cm^3 of a 1.0 mol dm^{-3} solution of *Y* and 50 cm^3 of a 1.0 mol dm^{-3} solution of *Z* were mixed, 20% of the initial amount of *X* had reacted during 4 seconds.

(i) Calculate the rate of consumption of *X*.

(ii) Deduce the rate of consumption of *Y*.

(iii) Write the rate expression for the above reaction.

When the above experiment was repeated by changing the concentration of *Z* while keeping the concentrations of *X* and *Y* constant, it was observed that the rate of the reaction didn't change. It has also been found that the above reaction occurs via the following two steps.

$X + Y \longrightarrow XY$ (slow) - activation energy, Ea_1

$XY + Y + Z \longrightarrow$ prducts (fast) - activation energy, Ea_2

(iv) Deduce the order of the reaction with respect to *X*, *Y* and *Z*.

(v) Obtain the rate expression.

(vi) Is *Z* essential for the above reaction? Explain your answer with reasons.

(vii) What is the rate determining step of the above reaction?

(viii) What is the molecularity of the rate determining step?

(ix) What is the intermediate of the above reaction.

(x) Draw a labelled energy profile for the above reaction.

(7.0 marks)

(*c*) An experiment to determine the relative atomic mass of magnesium was designed by a group of students. They reacted different masses of magnesium with hydrochloric acid and collected the hydrogen gas produced under the pressure of 1.0×10^5 Pa and 27°C temperature. Their results are tabulated below.

Mass of magnesium/mg	Volume of hydrogen gas/cm^3
35	34
33	32
34	33

(i) A student proposed that the burette or the measuring cylinder is suitable to collect hydrogen gas. Which volumetric instrument do you consider is more suitable?

(ii) State two strategies that should be followed when measuring the volume using that instrument.

(iii) Calculate the following using the above experimental data.

(I) Amount of moles of hydrogen gas produced.

(II) Amount of moles of magnesium reacted.

(III) Relative atomic mass of magnesium.

(iv) The correct relative atomic mass of magnesium is 24.31. If your answer is different from the correct value, give reasons.

(v) Explain giving reasons whether it is easier or more difficult to conduct the experiment if a hydrochloric acid solution of higher concentration is used.

(vi) A student proposed that it is better to weigh 100.0 mg of magnesium and measure the mass of remaining metal to get more accurate reading for the mass of magnesium. Explain giving reasons whether you agree or disagree with this idea.

(5.0 marks)

[see page ten

7. (*a*) (i) "Amines are considered basic compounds while alcohols are not considered so." Explain this statement referring to a primary amine and a primary alcohol.

(ii) Consider the following structures.

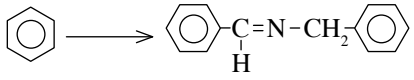


, $CH_3CH_2NH_2$

Which compound is more basic? Give reasons.

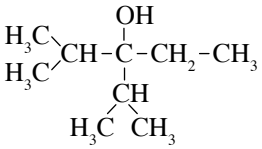
(4.0 marks)

(*b*) (i) Indicate how the following conversion can be effected.



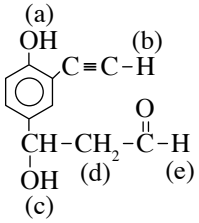
(5.2 marks)

(ii) Indicate how the following compound could be synthesized using propene ($CH_3-CH=CH_2$) as the only organic compound.



(4.8 marks)

(iii) Consider the following compound.



When the above compound is treated with the following reagents, state which of the H atoms labelled a, b, c, d, e is/are subject to reaction.

- sodium metal
- aqueous sodium hydroxide

(1.0 mark)

PART C - ESSAY

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

8. (*a*) This question is based on the element *A* which belongs to "p block" of the periodic table. Consider the following sequence of reactions relevant to the chemistry of *A*.

$$A \xrightarrow[\text{chlorine gas}]{\text{heating with excess}} B$$

$$\text{aqueous solution of } B \xrightarrow[\text{ammonia solution}]{\text{adding aqueous}} C \text{ (white gelatinous precipitate)}$$

$$C \xrightarrow{\text{strong heating}} D \text{ (white solid)}$$

$$D \xrightarrow[\text{hydroxide solution}]{\text{adding an aqueous sodium}} E \text{ (colourless solution)}$$

$$E \xrightarrow[\text{hydrochloric acid dropwise}]{\text{adding dilute}} C \text{ (precipitate)} \xrightarrow{\text{excess acid}} \text{aqueous solution of } B$$

$$A + \text{sodium hydroxide solution} \longrightarrow E + F \text{ (colourless gas)}$$

[see page eleven

(i) Identify A, B, C, D, E and F giving relevant chemical formulae.

(ii) Write the balanced chemical equation for the reaction between D and sodium hydroxide.

(iii) An aqueous solution of B turns blue litmus red. Explain this observation using the relevant chemical equation.

(iv) In vapour state, relative molecular mass of B is twice the expected value. What is the reason for this?

(4.0 marks)

(*b*) Consider the following sequence of reactions.

$$\text{air} \xrightarrow{\text{fractional distillation}} \begin{matrix} E \xrightarrow{R,\,\Delta} L \xrightarrow{H_2O} T \xrightarrow{CO_2} \text{turbidity} \\ + \\ Q \xrightarrow{R,\,\Delta} U \xrightarrow{H_2O} T + V \\ + \\ \text{other gases} \end{matrix}$$

The sulphate of R is slightly soluble in water.

(i) Identify E, Q, R, L, T, U and V giving relevant chemical name or formula.

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

(I) Q and R

(II) U and water

(iii) Write one use of L and two uses of V in addition to their laboratory use.

(4.0 marks)

(*c*) A metal ore consists of copper(II) sulphide and iron(II) sulphide as the chemical components of commercial importance. In order to find the percentage of copper, iron and sulphur by mass in the ore, the following experimental procedure was used.

Procedure :

1.000 g of a sample of the ore was heated with concentrated nitric acid till the sulphide ions were oxidised to sulphate ions and the ferrous ions (Fe^{2+}) were oxidised to ferric ions (Fe^{3+}).
The resulting solution was filtered to remove rocky impurities and the filtrate was diluted with distilled water to make the solution S of total volume 250 cm^3.
A 25.00 cm^3 portion of solution S was measured, acidified with dilute nitric acid and excess of barium chloride solution was added. The substance X precipated was filtered, dried and weighed. The mass of X was found to be 0.1864 g.
Another 25.00 cm^3 portion of S was acidified with sulphuric acid and excess 5% potassium iodide solution was added to it. The liberated iodine was titrated with a 0.0400 mol dm^{-3} sodium thiosulphate solution kept in the burette using starch as the indicator. At the end point the burette reading was 20.00 cm^3.
At the end of the titration, the white precipitate Y settled on the bottom of the titration flask was filtered, dried and weighed. The mass of Y was found to be 0.0381 g.

(i) Identify X and Y.

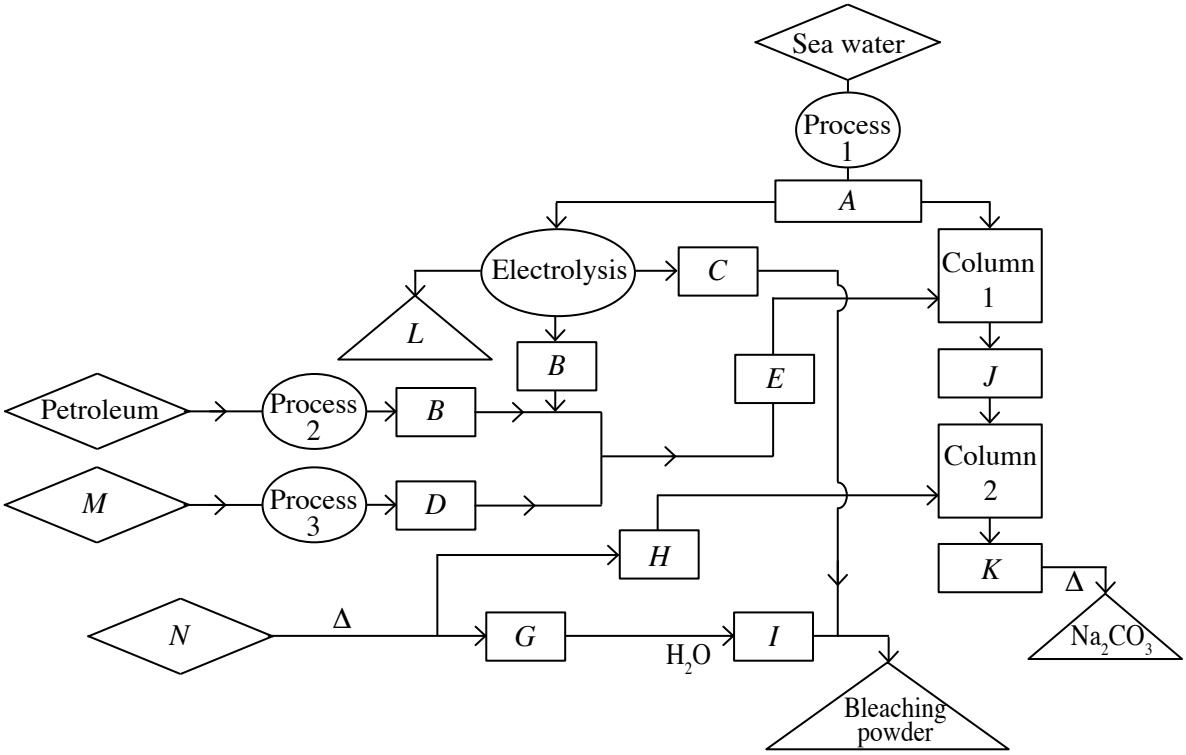
(ii) Write balanced ionic equations for the reactions occurred during the above procedure.

(iii) Calculate the percentage by mass of copper, iron and sulphur in the metal ore.
(relative atomic masses : Cu = 63.5, Fe = 56, S = 32, O = 16, Ba = 137, I = 127)

(7.0 marks)

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9. (*a*) The following flow chart represents the method of synthesising several products using natural raw materials including sea water. Rhombuses (◇) represent raw materials, rectangles (▭) represent intermediate products and triangles (△) represent the final products in this flow chart.



(i) Name the substances denoted by the English letters *A* to *N*. (Write the name or formula of the substance opposite each English letter.)

(ii) Indicate the processes 1, 2 and 3.

(iii) Write equations for the processes occuring in columns 1 and 2.

(iv) Write the balanced equation for the total reaction regarding the production of sodium carbonate by the above process.

(v) During this production process, column 1 and column 2 should be cooled. What is the reason for this?

(vi) Write the balanced equation for the final reaction in the production of bleaching powder.

(7.5 marks)

(*b*) The percentage of nitrogen gas in the atmosphere by volume is 78% and it has properties mostly similar to those of a noble gas. But some compounds of nitrogen contribute to adverse effects on the environment.

(i) Explain the reason why nitrogen gas behaves like a noble gas?

(ii) Write **two** gaseous compounds of nitrogen that contribute to envirnmental pollution.

(iii) State **three** processes that release the species you stated above to the environment.

(iv) Write **four** unfavourable environmental effects that are caused by the compounds you stated in (ii) above.

(v) Using reactions explain how atmospheric nitrogen contributes to two effects you stated in (iv).

(vi) State **two** methods that can be used to control the emission of the pollutants you stated in (ii) to the environment.

(7.5 marks)

[see page thirteen

10. (*a*) (i) Write the equilibrium reaction of the calomel electrode.

(ii) Represent in the IUPAC notation the cell prepared by connecting a standard chlorine electrode and the standard calomel electrode.

(iii) Calculate the standard electromotive force (e.m.f.) of the above cell. The standard electrode potentials of chlorine and calomel electrodes are +1.36 V and +0.24 V respectively.

(3.0 marks)

(*b*) (i) An aqueous solution of sodium sulphate is electrolysed by using magnesium electrodes. Write the anodic reaction, the cathodic reaction and the overall reaction.

(ii) 250 cm^3 of an aqueous solution of sodium sulphate is electrolysed using magnesium electrodes by passing a current of 50 mA. Calculate the time taken to form a slight turbidity in the solution.
(1 F = 96500 C, Solubility product of $Mg(OH)_2 = 4.0 \times 10^{-12}$ $mol^3\,dm^{-9}$)

(iii) State an assumption made in your calculation.

(5.0 marks)

(*c*) Aqueous Mn^{2+} ions can be oxidised to MnO_4^- by heating with concentrated nitric acid in the presence of lead dioxide (PbO_2). Lead dioxide is reduced to Pb^{2+} in this reaction. An experiment carried out to determine the percentage of manganese (Mn) by mass in an alloy using the above reaction is given below.

- Acidified potassium permanganate solution and water were mixed in test tubes as shown in the following table.

Test tube number	Volume of 0.05 mol dm^{-3} $KMnO_4$ solution/cm^3	Volume of water/cm^3
1	2.0	8.0
2	4.0	6.0
3	6.0	4.0
4	8.0	2.0
5	10.0	–

- 3.0 g of the alloy was heated with lead dioxide and excess concentrated nitric acid until the reaction was complete. After cooling, the solution obtained was diluted with distilled water to prepare an aqueous solution (*X*) of volume 250 cm^3.
It was found that the colour intensity of the solution formed by mixing 5.0 cm^3 of *X* and 5.0 cm^3 of water was exactly equal to the colour intensity of the solution in test tube 4.

(i) Write the balanced ionic equation for the reaction between Mn^{2+} and PbO_2 in acidic medium.

(ii) What are the factors that should be considered when selecting test tubes for the above experiment?

(iii) Calculate the percentage by mass of manganese in the alloy.
(relative atomic mass of Mn = 55)

(iv) State two important assumptions made in the above calculations.

(v) "Potassium permanganate is not a primary standard substance". Explain this statement.

(vi) State the necessary steps of an experiment that can be conducted to determine the accurate concentration of potassium permanganate solution required for the above reaction.

(vii) Write the balanced chemical equation for the reaction between a concentrated potassium hydroxide solution and a neutral potassium permanganate solution.

(viii) State the colour change you expect to observe in (vii) above.

(7.0 marks)

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