අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2021(2022)
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2021(2022)
General Certificate of Education (Adv. Level) Examination, 2021(2022)

රසායන විද්‍යාව I இரசாயனவியல் I **Chemistry I**	**02 E I**	පැය දෙකයි இரண்டு மணித்தியாலம் ***Two hours***

Instructions:

- ✻ *Periodic Table is provided.*
- ✻ *This paper consists of* **09** *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 from* (1), (2), (3), (4), (5) *which is* ***correct*** *or* ***most appropriate*** *and* ***mark your response on the answer sheet with a cross*** (×) ***in accordance with the instructions given on the back of the answer sheet.***

Universal gas constant $R = 8.314\ J\ K^{-1}\ mol^{-1}$ Planck's constant $h = 6.626 \times 10^{-34}\ J\ s$

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

1. Select the correct statement with regard to particles associated with cathode rays observed in a cathode ray tube.

(1) The particles are uncharged.

(2) They travel from anode to cathode along straight lines.

(3) Their charge to mass ratio $\frac{e}{m}$ depends on the nature of gas and pressure inside the cathode ray tube.

(4) Their direction of travel is affected by magnetic and electric fields.

(5) They are not capable of ionizing the gas inside the cathode ray tube.

2. Which of the following statements is **incorrect** with regard to an energy level of an atom with principal quantum number (n), n = 3?

(1) There are 3 sub shells associated with it.

(2) There are 9 orbitals.

(3) There can be a maximum of 18 electrons.

(4) There can be a maximum of 10 electrons with angular momentum (azimuthal) quantum number (l), $l = 2$.

(5) There can be a maximum of 8 electrons with magnetic quantum number (m_l), $m_l = 0$.

3. The **decreasing** order of the first ionization energy of the atoms H, He, Li, Be, B and Na is,

(1) He > H > B > Be > Li > Na

(2) He > H > Be > B > Li > Na

(3) He > Be > H > Li > B > Na

(4) H > He > B > Be > Li > Na

(5) H > He > Be > B > Na > Li

4. The shapes of IF_4^+, IF_4^- and IF_5 are respectively,

(1) see-saw, square planar and square pyramidal.

(2) square planar, see-saw and square pyramidal.

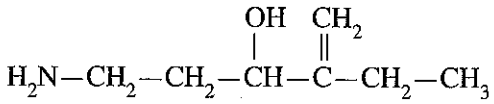
(3) tetrahedral, see-saw and trigonal bipyramidal.

(4) see-saw, tetrahedral and square pyramidal.

(5) tetrahedral, square planar and trigonal bipyramidal.

[*See page two*

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



(1) 1-amino-4-ethylpent-4-en-3-ol
(2) 5-amino-2-ethylpent-1-en-3-ol
(3) 2-ethyl-3-hydroxypent-1-en-5-amine
(4) 4-ethyl-3-hydroxypent-4-en-1-amine
(5) 5-amino-2-ethyl-3-hydroxypent-1-ene

6. Which of the following statements is correct with regard to boiling points?
(1) N_2 has a higher boiling point than NO.
(2) PH_3 has a higher boiling point than NH_3.
(3) Xe has a higher boiling point than Kr.
(4) CH_3CH_2OH has a higher boiling point than $CH_3CH_2CH_2OH$.
(5) CH_3CHCH_3 (CH$_3$ branch) has a higher boiling point than $CH_3CH_2CH_2CH_3$.

7. $M(OH)_2$ is a sparingly water soluble solid. The concentration of $M^{2+}(aq)$ in a saturated aqueous solution of $M(OH)_2$ at pH = 8.0 and at a given temperature is 1.0×10^{-6} mol dm^{-3}. The pH of a saturated aqueous solution of $M(OH)_2$ having $M^{2+}(aq)$ concentration of 1.0×10^{-4} mol dm^{-3} at this temperature is,
(1) 4.0 (2) 5.0 (3) 6.0 (4) 7.0 (5) 8.0

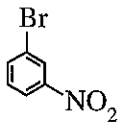
8. Select the correct statement.
(1) The electron pair geometry and shape of SF_5^+ are different from each other.
(2) The increasing order of radii of atoms/ions F^-, Mg^{2+}, Al, Cl^- and K is $F^- < Mg^{2+} < Cl^- < Al < K$.
(3) The number of resonance structures that can be drawn for nitric acid (HNO_3) is four.
(4) CO_3^{2-} has the longest C—O bond among the molecules/ions CO, CO_2, CO_3^{2-} and CH_3OH.
(5) Among the molecules CH_4, $COCl_2$ and HCN, the electronegativity of the carbon atom increases in the order $CH_4 < COCl_2 < HCN$.

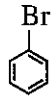
9. **A** and **B** are two organic compounds containing C, H and O. When **A** and **B** were separately treated with Br_2/H_2O, only **A** gave a white precipitate. The product formed when **B** was heated with concentrated H_2SO_4 decolourised Br_2/H_2O. The organic compounds **A** and **B** are respectively,

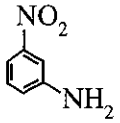
(1) C_6H_5OH, CH_3OH
(2) $C_6H_5CH_2OH$, CH_3CH_2OH
(3) C_6H_5OH, $CH_3CH(CH_3)CH_2OH$
(4) C_6H_5CHO, C_6H_5OH
(5) CH_3CHO, $CH_3CH(CH_3)CH_2OH$

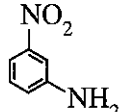
10. The elementary reaction $A(g) \rightarrow B(g) + C(g)$ occurs in a closed rigid container at constant temperature. The initial pressure of the container when only A(g) is present was measured to be $2P_0$. The pressure of the container after two half lives of A(g) would be,
(1) $\frac{P_0}{2}$ (2) $\frac{P_0}{4}$ (3) $\frac{3P_0}{4}$ (4) $\frac{3P_0}{2}$ (5) $\frac{7P_0}{2}$

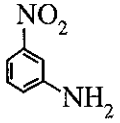
[*See page three*

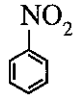
11. A suitable method to prepare  is,

(1)  $\xrightarrow{\text{conc. } HNO_3 / \text{conc. } H_2SO_4}$

(2)  $\xrightarrow[(2)\ Br_2/FeBr_3]{(1)\ NaNO_2/\text{dilute HCl}/0-5\ ^\circ C}$

(3)  $\xrightarrow[(2)\ \text{CuBr}]{(1)\ NaNO_2/\text{dilute HCl}/0-5\ ^\circ C}$

(4)  $\xrightarrow[(2)\ \text{CuBr}]{(1)\ NaNO_2/\text{dilute HCl}/25\ ^\circ C}$

(5)  $\xrightarrow{Br_2}$

12. Which expression gives the correct volume (cm^3) of 70.0% $\left(\frac{w}{w}\%\right)$ concentrated HNO_3 acid with density 1.42 g cm^{-3} required to prepare 300 cm^3 of a 0.150 mol dm^{-3} solution of HNO_3? (Relative atomic mass: H = 1, N = 14, O = 16)

(1) $\frac{100}{1.42}\times\frac{70.0}{63}\times\frac{0.150}{1000}\times 300$

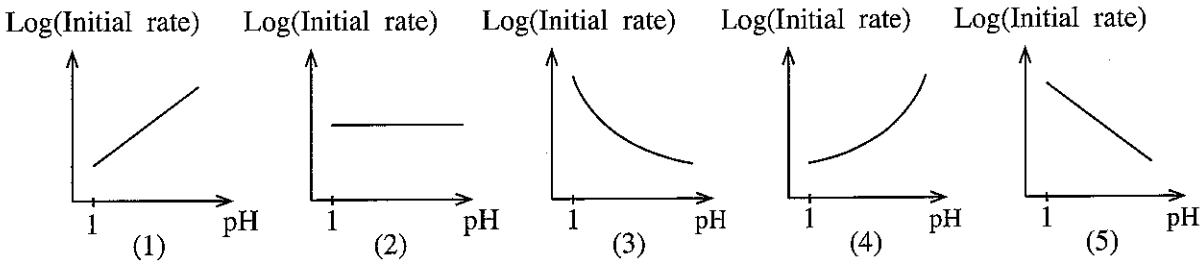
(2) $\frac{100}{1.42}\times\frac{63}{70.0}\times\frac{0.150}{1000}\times 300$

(3) $\frac{1.42}{100}\times\frac{63}{70.0}\times\frac{1000}{0.150}\times 300$

(4) $\frac{100}{1.42}\times\frac{63}{70.0}\times\frac{1000}{0.150}\times\frac{1}{300}$

(5) $\frac{1.42}{100}\times\frac{70.0}{63}\times\frac{0.150}{1000}\times 300$

13. The elementary reaction, $A(aq) + H_3O^+(aq) \rightarrow B^+(aq)$ occurs in an aqueous solution at constant temperature. Which of the following graphs correctly represents the relationship between Log(Initial rate) vs pH at a constant concentration of A(aq)?



14. An excess amount of A(g) and a small amount of B(g) are introduced into an evacuated rigid container. Then, the following elementary reactions take place at a constant temperature.

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

$A(g) + C(g) \rightarrow 3D(g)$ slow

Which of the following statements is correct regarding the variation of pressure of the system with time?

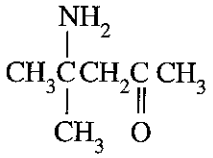
(1) Pressure remains unchanged.
(2) Pressure increases and then becomes constant.
(3) Pressure decreases and then becomes constant.
(4) Pressure decreases and returns to the initial value again.
(5) Pressure increases initially, then decreases and returns to the initial value again.

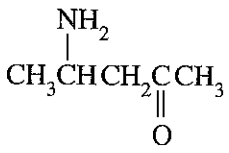
15. The solute **A** present in volume V of an aqueous solution is extracted twice using 2V volume portions of a water immiscible organic solvent. The partition coefficient of **A** between the organic solvent and water, $\frac{[\mathbf{A}]_{(org)}}{[\mathbf{A}]_{(aq)}} = 4.0$. The initial amount of **A** in the aqueous phase is a (mol). The amount (mol) of **A** remaining in the aqueous phase after the second extraction is,

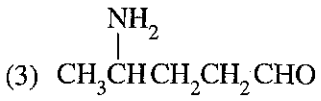
(1) $\frac{a}{2}$ (2) $\frac{a}{9}$ (3) $\frac{a}{18}$ (4) $\frac{a}{25}$ (5) $\frac{a}{81}$

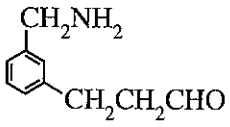
[See page four

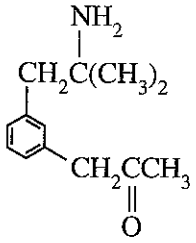
16. Compound **A** reacts with $NaNO_2$/dilute HCl to give **B**. When **B** is treated with acidified aqueous $K_2Cr_2O_7$, the solution turns green. When treated with Fehling's reagent **A** did not give a brick red precipitate. Compound **A** could be,

(1) 

(2) 

(3) 

(4) 

(5) 

17. MCl_2 is a solid which is sparingly soluble in water ($K_{sp} = 1.0 \times 10^{-8}$ mol^3 dm^{-9}). Which of the following is correct regarding a saturated aqueous solution of MCl_2?

(1) Evaporation of water from the solution increases M^{2+} and chloride ion concentrations of the solution.
(2) Chloride ion concentration of the solution can be increased by adding NaCl(s).
(3) The solution cannot be acidified by adding HCl.
(4) Chloride ion concentration of the solution cannot be increased above 1.0×10^{-4} mol dm^{-3}.
(5) Chloride ion concentration of the solution can be lowered by adding distilled water and maintaining the saturated condition.

18. When a mass of 0.0119 g of KBr is dissolved in 500.0 cm^3 of distilled water, the K^+ composition of the solution in mol dm^{-3} and ppm (mg kg^{-1}) are respectively,
(Relative atomic mass: K = 39, Br = 80; density of solution = 1.00 kg dm^{-3})

(1) 1.0×10^{-4} and 3.9
(2) 1.0×10^{-4} and 7.8
(3) 2.0×10^{-4} and 1.3
(4) 2.0×10^{-4} and 3.9
(5) 2.0×10^{-4} and 7.8

19. The correct reaction relevant to the standard enthalpy of hydration of the sodium ion is,

(1) $Na^+(g) + OH^-(aq) \longrightarrow NaOH(s)$
(2) $NaCl(g) + H_2O(l) \longrightarrow Na^+(aq) + OH^-(aq) + HCl(aq)$
(3) $Na^+(g) + H_2O(l) \longrightarrow Na^+(aq)$
(4) $Na^+(g) + H_2O(l) \longrightarrow Na^+(aq) + OH^-(aq) + H^+(aq)$
(5) $Na^+(g) + Cl^-(g) + H_2O(l) \longrightarrow Na^+(aq) + Cl^-(aq)$

20. Which of the following is **not** a step in the chlorination of methane?

(1) $Cl_2 \xrightarrow{h\nu} 2Cl^\bullet$
(2) $CH_4 + {}^\bullet Cl \longrightarrow {}^\bullet CH_3 + HCl$
(3) ${}^\bullet CH_3 + Cl_2 \longrightarrow CH_3Cl + Cl^\bullet$
(4) $CH_3Cl + Cl^\bullet \longrightarrow {}^\bullet CH_2Cl + HCl$
(5) ${}^\bullet CH_2Cl + HCl \longrightarrow CH_2Cl_2 + H^\bullet$

21. Which of the following statements regarding the critical temperature of a real gas is correct?

(1) It is the temperature at which the intermolecular forces can be neglected.
(2) It is the temperature corresponding to the lowest pressure at which the gas can be liquified.
(3) It is the temperature at which the gas is in equilibrium with its solid.
(4) It is the highest temperature at which the gas phase and the liquid phase are in equilibrium.
(5) It is the temperature given by the van der Waals equation at any pressure.

[*See page five*

22. In an experiment, Mg metal was made to react with excess N_2 gas and the product obtained was reacted with H_2O. The volume of the gas evolved at standard temperature (273 K) and pressure (1.0 atm) was 672 cm^3. The mass of Mg used in the experiment is,
(Assume that 1.0 mol of gas occupies a volume of 22.4 dm^3 at 273 K and 1.0 atm.
Relative atomic mass: Mg = 24)

(1) 0.24 g (2) 0.48 g (3) 0.72 g (4) 1.08 g (5) 1.50 g

23. The mean square speed of H_2 at absolute temperature T is equal to the mean square speed of N_2 at absolute temperature T'. Which of the following equations gives the correct relationship between T and T'? (Relative atomic mass: H = 1, N = 14)

(1) $T = T'$ (2) $T = 14T'$ (3) $T = \frac{T'}{4}$ (4) $T = 7T'$ (5) $T = \frac{T'}{14}$

24. A buffer solution at constant temperature contains a monobasic weak acid ($K_a = 1.00 \times 10^{-5}$ mol dm^{-3}) and its sodium salt. The concentrations of the weak acid and the sodium salt in the solution are 0.10 mol dm^{-3} each. The volume of 1.00 mol dm^{-3} weak acid that should be added to change the pH of 10.00 cm^3 of this solution by one unit, and the pH value of the solution after the addition of the weak acid are respectively,

(1) 9.00 cm^3, 4.0 (2) 9.00 cm^3, 6.0 (3) 10.00 cm^3, 4.0
(4) 10.00 cm^3, 5.0 (5) 11.00 cm^3, 4.0

25. A gaseous discharge/production that contributes to all three environmental issues, namely, global warming, acid rain and photochemical smog is,

(1) exhaust gas released from fossil fuel burning vehicles.
(2) exhaust gas released from coal power plants.
(3) gases released during repair of air conditioners and refrigerators.
(4) gases produced from the improper discharge of municipal solid waste.
(5) exhaust gas released from biofuel burning vehicles.

26. Which of the following statements is **incorrect** with regard to element Lithium (Li) and its compounds?

(1) Among the Group I elements from Li – Cs, lithium has the most negative value for electron gain energy.
(2) Lithium forms two products when heated in air.
(3) Considering the gases evolved, upon heating $LiNO_3(s)$ produces two gases whereas $Li_2CO_3(s)$ gives only one gas.
(4) Among Group I elements, lithium has the weakest metallic bonding.
(5) Lithium gives a red coloured flame in the flame test.

27. The number of moles of $KMnO_4$ that are required to react completely with one mole of $Fe(NO_2)_2$ in acidic medium is,

(**Note:** Neglect the loss of NO_2^- due to acidic conditions.)

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

28. Which of the following statements is correct regarding water and aqueous solutions at a given temperature?

(1) The solubility of a polar gas in water is lower than the solubility of a non polar gas in water.
(2) Any gas undergoes ionization in an aqueous solution.
(3) The solubility of a gas in water is proportional to its pressure.
(4) Boiling point of water decreases with increasing pressure.
(5) The temperature of the triple point of water increases with increasing pressure.

[*See page six*

29. Select the correct statement with regard to chromium (Cr) and its compounds.
(1) When an aqueous solution of K_2CrO_4 is treated with dilute H_2SO_4, a colour change is not observed.
(2) The electronegativity of Cr is greater than that of Co.
(3) An aqueous solution of $Cr(H_2O)_6^{2+}$ when treated with excess NaOH, followed by the addition of H_2O_2 gives a yellow coloured solution.
(4) Cr_2O_3 shows basic properties.
(5) When H_2S gas is passed into an acidic solution of $K_2Cr_2O_7$, a clear green coloured solution is observed.

30. Which of the following statements is **incorrect** regarding carboxylic acids?
(1) The product formed by the reaction of a carboxylic acid with $LiAlH_4$ gives an alcohol upon hydrolysis.
(2) Carbon dioxide is liberated when carboxylic acids are reacted with aqueous NaOH.
(3) Carboxylic acids react with PCl_5 to give acid chlorides.
(4) Methane is liberated when carboxylic acids are reacted with CH_3MgBr.
(5) Carboxylic acids are formed when aldehydes are treated with $H^+/K_2Cr_2O_7$.

● 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 give(s) 3-bromo-3-methylhexane as the major product when reacted with HBr?

(*a*) $CH_3CH_2CH_2\overset{\overset{CH_3}{|}}{C}=CHCH_3$

(*b*) $CH_3CH_2CH_2\overset{\overset{CH_3}{|}}{C}HCH=CH_2$

(*c*) $CH_3CH=CH\overset{\overset{CH_3}{|}}{C}HCH_2CH_3$

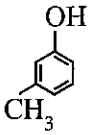
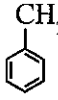
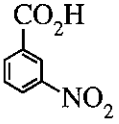
(*d*) $CH_3CH_2CH_2\overset{\overset{CH_2CH_3}{|}}{C}=CH_2$

32. Which of the following statements is/are correct regarding products related to plant sources?
(*a*) Essential oils contain complex mixtures of volatile constituents of plants.
(*b*) Biodiesel is produced from volatile plant oils.
(*c*) Methanol is not used in the production of biodiesel.
(*d*) Ethanol produced by fermentation of plant materials is regarded as a renewable energy source.

33. On which of the following factor/factors does the electrode potential of the electrode $M^{2+}(aq)/M(s)$ depend?
(*a*) Surface area of M(s)
(*b*) Concentration of $M^{2+}(aq)$
(*c*) Temperature
(*d*) Volume of $M^{2+}(aq)$ solution

[*See page seven*

34. Which of the following give(s) CO_2 when treated with aqueous Na_2CO_3?

(*a*)  (*b*)  (*c*)  (*d*) 

35. Which of the following statements is/are always correct regarding an aqueous solution of a weak electrolyte?

(*a*) When conducting an electric current, the fraction of the current carried by the anion is greater than the fraction of the current carried by the cation.
(*b*) The conductivity of the anion is greater than the conductivity of the cation.
(*c*) Only a small percentage of molecules of the weak electrolyte is dissociated into ions.
(*d*) The fraction of molecules of the weak electrolyte dissociated increases with dilution.

36. Which of the following statements is/are correct regarding the relationship between global environmental issues and volatile halogenated hydrocarbons?

(*a*) CFC, HCFC and HFC all three contribute to global warming.
(*b*) CFC contributes to ozone layer depletion by producing chlorine radicals in the troposphere.
(*c*) HFC contributes to ozone layer depletion by producing chlorine radicals in the stratosphere.
(*d*) Both CFC and HCFC contribute to ozone layer depletion by producing chlorine radicals in the stratosphere.

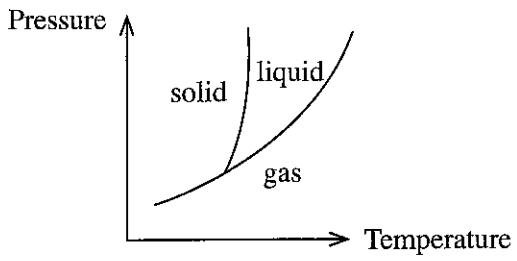
37. Which of the following statements is/are correct with regard to the two allotropes of carbon, namely, graphite and diamond?

(*a*) Carbon atoms in diamond are tetrahedrally surrounded by four other carbon atoms to give a three-dimensional lattice.
(*b*) Because graphite is composed of two-dimensional layers held together by weak van der Waals forces (secondary interactions), it acts as a good lubricant.
(*c*) Diamond is a good conductor of heat and electricity.
(*d*) Graphite has a considerably higher melting point than diamond.

38. Which of the following statements is/are correct regarding gases?

(*a*) Molecules move at different speeds in a sample of a real gas whereas all the molecules move at the same speed in a sample of an ideal gas.
(*b*) Ideal gases can be liquified at extremely high pressures.
(*c*) The Maxwell-Boltzmann speed distribution curve of an ideal gas is symmetric about the maximum point.
(*d*) The compressibility factor of a real gas depends on pressure.

39.



Which of the following statements is/are correct regarding the phase diagram of a pure substance given above?

(*a*) The number of molecules in a unit volume is always higher in the gas phase than in the liquid phase.
(*b*) The liquid phase and the gas phase never co-exist at the same temperature.
(*c*) The solid phase and the gas phase never co-exist at the same pressure.
(*d*) When the system is at the triple point, the rate at which the gas is converted to the liquid is equal to the rate at which the liquid is converted to the gas.

[*See page eight*

40. Which of the following statements is/are correct regarding the given industrial processes?

(*a*) Sea water can be used directly as a raw material in the extraction of Mg by the Dow process.

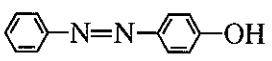
(*b*) In the production of NaOH, the use of membrane cells is more environmentally friendly than the use of mercury cells.

(*c*) The efficiency of the Solvay process used to produce Na_2CO_3 can be increased by cooling the ammonification tower.

(*d*) Rh metal is used as a catalyst in the production of H_2SO_4 by the contact process.

● 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** explain the first statement correctly
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	Second statement
41.	When an acidic solution of MnO_4^- is treated with H_2O_2, it turns colourless with the evolution of O_2, whereas, an acidic solution of Fe^{2+} on treatment with H_2O_2 turns yellow-brown.	H_2O_2 can act as an oxidizing agent as well as a reducing agent in acidic medium.
42.	Energy of a gas in a closed rigid container with thermally insulated walls remains constant.	Both energy and matter of an isolated system do not exchange with the surroundings.
43.	Cl_2 gas undergoes disproportionation on reaction with water giving HOCl(aq) and HCl(aq).	HOCl has the highest oxidizing ability among the oxoacids of chlorine.
44.	When a catalyst is added, the position of equilibrium of a reversible reaction changes.	A catalyst always increases the rate of the forward reaction more than the rate of the reverse reaction.
45.	$RC{\equiv}CMgBr$ can be prepared by the reaction between $RC{\equiv}CH$ and methylmagnesium bromide.	The alkyl group of a Grignard reagent can react as a base.
46.	Reaction of HCN with any aldehyde gives a product containing a chiral carbon atom.	A carbon atom joined to four different groups is called a chiral carbon atom.
47.	The main by-product in the production of Na_2CO_3 by the Solvay process is $CaCl_2$.	CaO is used to regenerate NH_3 in the Solvay process.
48.	Benzenediazonium chloride reacts with phenol in the presence of aqueous NaOH to give the following compound. 	Diazonium ions can react as electrophiles.
49.	When strong acids are titrated with aqueous ammonia, a neutral solution is not obtained at the equivalence point.	NH_4^+ reacts with water forming H_3O^+.
50.	Atomic oxygen is an essential factor for the formation of ozone in the atmosphere.	Atomic oxygen in the atmosphere is produced only by decomposition of molecular oxygen.

* * *

ආවර්තිතා වගුව/ஆவர்த்தன அட்டவணை/The Periodic Table

	1																2
1	**H**																**He**
	3	4											5	6	7	8	9	10
2	**Li**	**Be**											**B**	**C**	**N**	**O**	**F**	**Ne**
	11	12											13	14	15	16	17	18
3	**Na**	**Mg**											**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
4	**K**	**Ca**	**Sc**	**Ti**	**V**	**Cr**	**Mn**	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Ge**	**As**	**Se**	**Br**	**Kr**
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
5	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Mo**	**Tc**	**Ru**	**Rh**	**Pd**	**Ag**	**Cd**	**In**	**Sn**	**Sb**	**Te**	**I**	**Xe**
	55	56	**La-**	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
6	**Cs**	**Ba**	**Lu**	**Hf**	**Ta**	**W**	**Re**	**Os**	**Ir**	**Pt**	**Au**	**Hg**	**Tl**	**Pb**	**Bi**	**Po**	**At**	**Rn**
	87	88	**Ac-**	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
7	**Fr**	**Ra**	**Lr**	**Rf**	**Db**	**Sg**	**Bh**	**Hs**	**Mt**	**Ds**	**Rg**	**Cn**	**Nh**	**Fl**	**Mc**	**Lv**	**Ts**	**Og**

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

8560

AL/2021(2022)/02/E-II(A)

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2021(2022)
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2021(2022)
General Certificate of Education (Adv. Level) Examination, 2021(2022)

රසායන විද්‍යාව	II
இரசாயனவியல்	II
Chemistry	**II**

02 E II

පැය තුනයි	
மூன்று மணித்தியாலம்	
Three hours	

අමතර කියවීම් කාලය	-	මිනිත්තු 10 යි
மேலதிக வாசிப்பு நேரம்	-	10 நிமிடங்கள்
Additional Reading Time	-	**10 minutes**

Use **additional reading time** to go through the question paper, select the questions and decide on the questions that you give priority in answering.

Index No. : .....

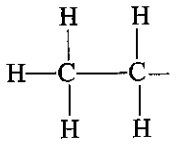
* *A Periodic Table is provided on page* 16.

* ***Use of calculators is not allowed.***

* *Universal gas constant,* $R = 8.314\ J\ K^{-1}\ mol^{-1}$

* *Avogadro constant,* $N_A = 6.022 \times 10^{23}\ mol^{-1}$

* **In answering this paper, you may represent alkyl groups in a condensed manner.**

Example:  group may be shown as CH_3CH_2-

❑ PART A — Structured Essay (pages 02 - 08)

* *Answer* ***all*** *the questions on the question paper itself.*

* *Write your answer in the space provided for each question. Please note that the space provided is sufficient for the answer and that extensive answers are not expected.*

❑ PART B and PART C — Essay (pages 09 - 15)

* *Answer* ***four*** *questions selecting* ***two*** *questions from each part. Use the papers supplied for this purpose.*

* *At the end of the time allotted for this paper, tie the answers to the three Parts* **A**, **B** *and* **C** *together so that Part* **A** *is on top and hand them over to the Supervisor.*

* *You are permitted to remove* **only** *Parts* **B** *and* **C** *of the question paper from the Examination Hall.*

For Examiner's Use Only

Part	Question No.	Marks
A	1	
	2	
	3	
	4	
B	5	
	6	
	7	
C	8	
	9	
	10	
Total		

Total

In Numbers	
In Letters	

Code Numbers

Marking Examiner 1	
Marking Examiner 2	
Checked by :	
Supervised by :	

[see page two

PART A — STRUCTURED ESSAY

*Answer **all four** questions on this paper itself. (Each question carries **100** marks.)*

Do not write in this column.

1. (*a*) State whether the following statements are **true** or **false** on the dotted lines. Reasons are not required.

(i) Rules related to polarizing power of cations and polarizability of anions predict that the melting point of KBr is higher than that of LiI. .....

(ii) The electron gain energy of Be is positive. .....

(iii) The spacing between two adjacent lines in a given series of the atomic spectrum of hydrogen decreases gradually in the direction of decreasing wavelengths. .....

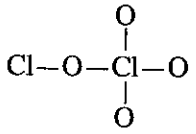
(iv) The de Broglie wavelength associated with the N_2 molecule is shorter than the de Broglie wavelength of the O_2 molecule when travelling at the same velocity. .....

(v) The effective nuclear charge (Z_{eff}) felt by a valence electron of C is greater than the effective nuclear charge felt by a valence electron of N. .....

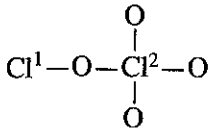
(vi) All C–O bonds in carbonic acid (H_2CO_3) are equal in length. .....

(24 *marks*)

(*b*) (i) Draw the **most** acceptable Lewis dot-dash structure for the molecule Cl_2O_4. Its skeleton is given below.

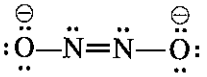


(ii) Give the oxidation states of the two chlorine atoms in the structure drawn in (i) above. The chlorine atoms are labelled as follows.

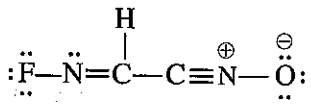


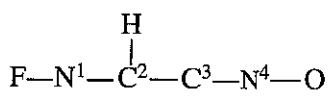
Cl^1 ..... , Cl^2 .....

(iii) The **most** stable Lewis dot-dash structure for the ion $N_2O_2^{2-}$ is shown below. Draw **two** additional Lewis dot-dash structures (resonance structures) for this ion.



(iv) Complete the given table based on the Lewis dot-dash structure and its labelled skeleton given below.





		N^1	C^2	C^3	N^4
I.	VSEPR pairs around the atom				
II.	electron pair geometry around the atom				
III.	shape around the atom				
IV.	hybridization of the atom				

[*see page three*

Do not write in this column.

- Parts (v) to (viii) are based on the Lewis dot-dash structure given in part (iv) above. Labelling of atoms is as in part (iv).

(v) Identify the atomic/hybrid orbitals involved in the formation of σ bonds between the two atoms given below.

I.	N^1—F	N^1	F .....
II.	N^1—C^2	N^1	C^2 .....
III.	C^2—H	C^2	H .....
IV.	C^2—C^3	C^2	C^3 .....
V.	C^3—N^4	C^3	N^4 .....
VI.	N^4—O	N^4	O .....

(vi) Identify the atomic orbitals involved in the formation of π bonds between the two atoms given below.

I.	N^1—C^2	N^1	C^2 .....
II.	C^3—N^4	C^3	N^4 .....
		C^3	N^4 .....

(vii) State the approximate bond angles around N^1, C^2, C^3 and N^4 atoms.

N^1....., C^2 ....., C^3 ....., N^4.....

(viii) Arrange the atoms N^1, C^2, C^3 and N^4 in the **increasing** order of electronegativity.

..... < ..... < ..... < ..... **(54 *marks*)**

(*c*) (i) A laser emits photons of wavelength 695 nm.

I. To which region of the electromagnetic spectrum do these photons belong?

.....

II. Calculate the energy of a mole of these photons in kJ mol^{-1}.
Velocity of light $c = 3.00 \times 10^8$ m s^{-1} Planck constant $h = 6.63 \times 10^{-34}$ J s

(ii) A molecule of formula AX_3 has **three** A–X σ bonds. Here, A and X represent symbols of elements and A is the central atom.
Name the molecular shape(s) possible for AX_3 in I and II given below.

I. if AX_3 is polar .....

II. if AX_3 is non-polar .....

III. Give **one** example each, for the shapes stated by you in I and II above.
(**Note:** Molecular formulae are required.)

AX_3 is polar .....

AX_3 is non-polar ..... **(22 *marks*)**

100

[*see page four*

Do not write in this column.

2. The questions [(*a*)–(*d*)] given below relate to elements/species designated as **A**, **B**, **C** and **D**.

(*a*) **A** is a *s*-block element. It has an atomic number less than 20. It reacts with water vigorously with ignition to give a strongly basic solution, with the evolution of a gas. **A** reacts with excess $O_2(g)$ to give the superoxide. The naturally occurring ore Sylvite contains a compound of **A**.

(i) Write the chemical symbol of **A**. .....

(ii) Write the complete electronic configuration of **A**. .....

(iii) Name the gas evolved in the reaction of **A** with water. .....

(iv) What is the colour given by **A** in the flame test? .....

(v) Write the balanced chemical equation for the reaction of **A** with excess $O_2(g)$.

.....

(vi) Is the first ionization energy of **A** higher or lower than that of the element in the same group and the period above it in the Periodic Table? Briefly explain your answer.

.....

.....

(vii) Give the chemical formula of the compound of **A** in Sylvite. .....

(35 *marks*)

(*b*) **B** is an anion containing only the two elements **X** and **Y**, in the ratio 2:3 respectively. Both **X** and **Y** are *p*-block elements that belong to the same group in the Periodic Table. The atomic number of each element is less than 20. The electronegativity of **X** is less than the electronegativity of **Y**. When **X** reacts with hot concentrated sulfuric acid, a colourless gas with a pungent smell is evolved as one of the products.

(i) Write the chemical formula, including the charge, of **B**. .....

(ii) Draw the Lewis dot-dash structure of **B**.

(iii) Give the oxidation state of the central atom of **B**. .....

(iv) Give a chemical test to identify **B**. (**Note:** Observation(s) is/are also required.)

.....

.....

(v) Write the chemical formula for the compound which has **A** as the cation and **B** as the anion.

.....

(25 *marks*)

(*c*) **C** is an oxidizing agent. It is composed of three elements in the ratio 1:1:3. One of the elements of **C** is **A**. The other two elements belong to the *p*-block of the Periodic Table. One of these two elements is also present in **B**. The salt formed between Ag^+ and the anion of one of these elements is yellow in colour, and insoluble in concentrated ammonia solution. Write the chemical formula of **C**.

.....

(10 *marks*)

[*see page five*

Do not write in this column.

(*d*) **D** is a compound composed of two elements. Both these elements are also present in **C**.

(i) When **C**(aq) is mixed with an excess of **D**(aq) in acidic medium, a reddish-brown solution results.

I. Identify **D**. .....

II. Write the balanced **ionic** equation for the reaction that takes place.

.....

(ii) On addition of an excess of a solution containing **B**, to the reddish-brown solution obtained in (i) above, the reddish-brown solution becomes colourless. Write the balanced **ionic** equation for the reaction that takes place.

.....

(iii) The concentration of a solution containing **B** can be determined by volumetric analysis utilizing the reactions in (i) and (ii) above. State an indicator which can be used and give the expected colour change at the end point.

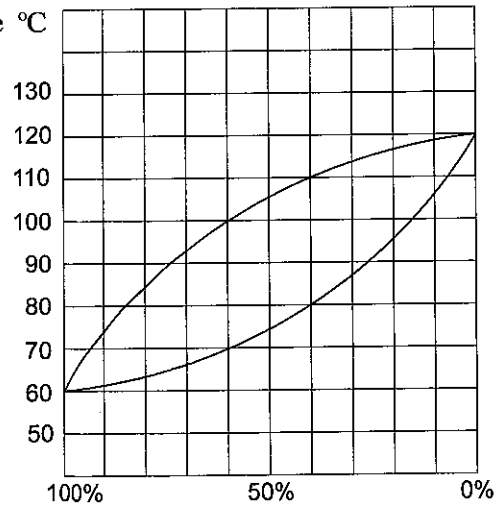
Indicator : .....

Colour change : .....

(30 *marks*)

100

3. (*a*) **X** and **Y** are two volatile liquids that form an ideal solution. The temperature-composition phase diagram (at a pressure of 1.0×10^5 Pa) for a system containing **X** and **Y** is given below.



- Parts (i) to (v) are based on the given phase diagram.

(i) Indicate the following regions on the phase diagram by writing the letters P, Q, R.

P – region where only the liquid phase is present

Q – region where only the vapour phase is present

R – region where the liquid phase and the vapour phase are in equilibrium

(ii) Give the boiling points of pure **X** and pure **Y**.

X ..... **Y** .....

(iii) What is the temperature at which a liquid mixture of **X** and **Y** containing 40 mol% of **X** begins to boil?

.....

(iv) What is the lowest temperature at which a mixture of **X** and **Y** containing 60 mol% of **X** is completely converted to vapour?

.....

[*see page six*

Do not write in this column.

(v) Calculate the saturated vapour pressure of **X** at the temperature of 100 °C.

(vi) In a separate experiment, a mixture containing **X** and **Y** was allowed to reach equilibrium in a **closed rigid** container at temperature T. It was then found that the liquid phase in equilibrium with the vapour phase contained 0.10 mol of **X** and 0.10 mol of **Y**. Saturated vapour pressures of **X** and **Y** at this temperature are 4.0×10^5 Pa and 2.0×10^5 Pa, respectively. Using Raoult law, calculate the partial pressures of **X** and **Y**.

(50 *marks*)

(*b*) The concentration of an aqueous solution of acetic acid (solution **Z**) was determined by titrating with an aqueous solution of NaOH. A volume of 12.50 cm^3 of solution **Z** required 25.00 cm^3 of NaOH solution of concentration 0.050 mol dm^{-3} to reach the end point.

(i) Calculate the concentration of acetic acid in solution **Z**.

(ii) Calculate the pH value of solution **Z**. Acid dissociation constant of acetic acid (K_a) at the temperature at which the experiment was carried out is 1.80×10^{-5} mol dm^{-3}.

(iii) To another portion (100.00 cm^3) of solution **Z**, 0.200 g of pure solid NaOH was added and dissolved. Calculate the pH value of this solution assuming that the volume and the temperature of the solution remain unchanged.
[Relative atomic mass: Na = 23, O = 16, H = 1]

[*see page seven*

Do not write in this column.

(iv) Does the solution described in (iii) above behave as a buffer solution? Explain your answer.

.....

.....

(v) In a separate experiment, 0.800 g of pure solid NaOH was dissolved in a 100.00 cm^3 volume of solution **Z**. Does this solution behave as a buffer solution? Explain your answer using a suitable calculation. Assume that the volume and temperature of the solution remain unchanged.

.....

.....

.....

.....

(50 *marks*)

100

4. (*a*) **A**, **B** and **C** are structural isomers having the molecular formula $C_5H_{11}Br$. Of these three isomers, only **B** exhibits optical isomerism. **A** and **C** are positional isomers of each other. When **A**, **B** and **C** were reacted separately with aqueous NaOH, compounds **D**, **E** and **F** having the molecular formula $C_5H_{12}O$ were formed respectively. **D**, **E** and **F** were treated separately with PCC. **F** did not react with PCC. **D** and **E** reacted with PCC and gave **G** and **H** respectively. Both compounds **G** and **H** gave coloured precipitates with 2,4–dinitrophenylhydrazine (2,4–DNP) and silver mirrors with ammonical $AgNO_3$.

Draw the structures of **A**, **B**, **C**, **D**, **E**, **F**, **G** and **H** in the boxes given below.

A

B

C

D

E

F

G

H

(56 *marks*)

[*see page eight*

Do not write in this column.

(*b*) Draw the structures of the products **I**, **J**, **K** and **L** of the following reactions, in the given boxes.

(i) $CH_3\overset{\overset{O}{\|}}{C}OCH_3$ $\xrightarrow[(2)\ H^+ / H_2O]{(1)\ CH_3MgBr\ (excess)/dry\ ether}$

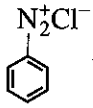
I

(ii) $C_2H_5C \equiv CH$ $\xrightarrow{dilute\ H_2SO_4 / Hg^{2+}}$

J

(iii) $CH_3\overset{\overset{O}{\|}}{C}CH_3$ $\xrightarrow[(2)\ H^+ / \Delta]{(1)\ aqueous\ NaOH}$

K

(iv)  $\xrightarrow{KI}$

L

(24 *marks*)

(*c*) Give the mechanism and the structure of the product formed for the reaction between $CH_3CH = CHCH_3$ and Br_2/CCl_4.

(20 *marks*)

100

* *

[*see page nine*

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கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2021(2022)
General Certificate of Education (Adv. Level) Examination, 2021(2022)

රසායන විද්‍යාව II இரசாயனவியல் II **Chemistry II**	**02 E II**

* Universal gas constant $R = 8.314\ J\ K^{-1}\ mol^{-1}$

* Avogadro constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$

PART B — ESSAY

*Answer **two** questions only. (Each question carries **150 marks**.)*

5. (*a*) (i) A gas mixture containing CH_4, C_2H_6 and excess O_2 was introduced into an evacuated closed rigid container. The volume of the container was $8.314 \times 10^{-3}\ m^3$. The pressure of the container at 400 K was 4.80×10^6 Pa. Calculate the total number of moles of gases in the container. Assume that all the gases behave ideally and that there is no reaction at this temperature.

(ii) All the hydrocarbons in the container were completely combusted by increasing the temperature of the container to 800 K. The pressure of the container after the combustion reactions at 800 K was 1.00×10^7 Pa. Calculate the total number of moles of gases in the container after combustion. Assume that H_2O is present as a gas under these conditions.

(iii) Write balanced chemical equations (giving physical states, at 800 K) for the combustion reactions of the gases given below.

I. $CH_4(g)$

II. $C_2H_6(g)$

(iv) Only one of the two hydrocarbons above contributes to the change in the number of moles of gases before and after combustion.
Calculate the number of moles of this hydrocarbon initially introduced into the container.

(v) The container was then cooled to 300 K and the water was removed. Then the pressure of the container was 2.10×10^6 Pa.
Calculate the following.

I. Total number of moles of H_2O produced

II. Number of moles of H_2O produced from the combustion of C_2H_6

III. Number of moles of H_2O produced from the combustion of CH_4

IV. Number of moles of O_2 introduced initially into the container **(75 *marks*)**

(*b*) (i) Using a **thermochemical cycle** and the data given, calculate the standard enthalpy change for the reaction given below.

$$4\ CH_4(g) + O_2(g) \longrightarrow 2\ C_2H_6(g) + 2\ H_2O(g)$$

	$\left(\Delta H_f^\circ\right)$ (kJ mol^{-1})	S° (J mol^{-1} K^{-1})
$CH_4(g)$	–74.8	186.3
$C_2H_6(g)$	–84.7	229.6
$CO_2(g)$	–393.5	213.7
$H_2O(g)$	–214.8	188.8
C(s), graphite	0.0	5.7
$O_2(g)$	0.0	205.1
$H_2(g)$	0.0	130.7

[*see page ten*

(ii) Calculate the standard entropy change for the reaction in (*b*)(i) above.

(iii) Calculate the standard Gibbs energy change (ΔG°) for the reaction in (*b*)(i) above at 500 K.

(iv) State, giving reasons, whether increase in temperature favours the reaction in (*b*)(i) above. Assume that the enthalpy change and entropy change are independent of temperature.

(75 *marks*)

6. (*a*) (i) Consider the reversible reaction **a A(aq) ⇌ b B(aq) + c C(aq)** that occurs in the aqueous medium. Considering that both forward and reverse steps are elementary reactions, write expressions for the rate of the forward reaction (R_1) and the rate of the reverse reaction (R_2). Rate constants for the forward reaction and the reverse reaction are k_1 and k_2, respectively.

(ii) Write the relationship between R_1 and R_2 at equilibrium.

(iii) Write down the expression for equilibrium constant K_C. Also give the relationship between K_C, k_1 and k_2.

(iv) To study the above equilibrium, three experiments were carried out at a constant temperature. In these experiments, different amounts of A, B and C were mixed, and the system was allowed to reach equilibrium. The following data were obtained at equilibrium.

Experiment Number	**Concentration at equilibrium (mol dm^{-3})**		
	[A]	[B]	[C]
1	1.0×10^{-1}	1.0×10^{-2}	1.0×10^{-3}
2	1.0×10^{-2}	1.0×10^{-3}	1.0×10^{-3}
3	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-5}

I. Obtain three relationships by substituting the concentrations of A, B and C given in the table for experiments 1, 2 and 3 in the equilibrium constant expression written in (*a*)(iii) above.

II. Prove that a = b = 2c using these relationships.

III. Using the smallest integers for the stoichiometric coefficients a, b and c, calculate the value of the equilibrium constant, K_C of the above reaction.

(80 *marks*)

(*b*) Consider the reaction, **p P(g) ⇌ q Q(g) + r R(g)** that takes place in gas phase.

(i) The enthalpy change and activation energy of the forward reaction, **p P(g) ⟶ q Q(g) + r R(g)** are 50.0 kJ mol^{-1} and 90.0 kJ mol^{-1}, respectively. Draw the labelled energy diagram (the graph of energy vs reaction coordinate) for this reaction. Show the positions of P, Q and R by marking them on the energy diagram. Also, mark the position of the activated complex as 'activated complex' on it.

(ii) Calculate the activation energy for the reverse reaction.

(iii) Explain the effect of increasing temperature on the equilibrium constant of this reaction.

(iv) Explain the effect of a catalyst

I. on the rates of forward and reverse reactions.

II. on the equilibrium constant.

(70 *marks*)

[*see page eleven*

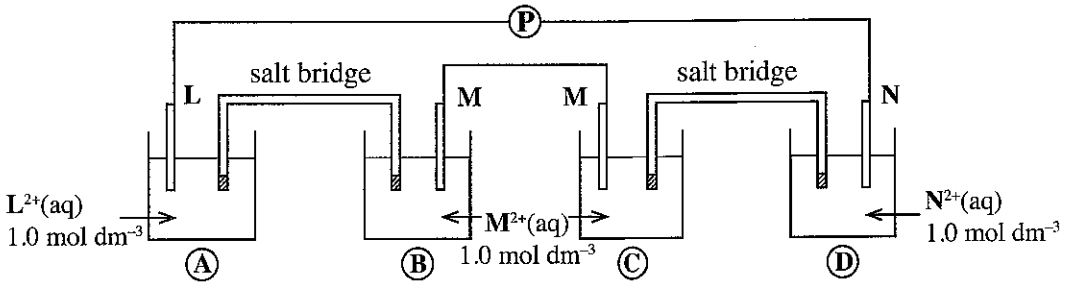
7. (*a*) You are provided with the three metal rods **L**, **M**, **N** and the three solutions L^{2+} (1.0 mol dm^{-3}), M^{2+} (1.0 mol dm^{-3}), N^{2+} (1.0 mol dm^{-3}). When the metal **N** is dipped in the solution of M^{2+} ions, M^{2+} is reduced to **M**, whereas when **N** is dipped in the solution of L^{2+} ions, L^{2+} does not get reduced to **L**.

(i) Giving reasons arrange the three metals, **L**, **M** and **N** in the increasing order of their reducing ability.

(ii) Electromotive forces of the two electrochemical cells prepared using $L^{2+}(aq)/\ L(s)$ electrode and each of the other two electrodes are +0.30 V and +1.10 V. Using this information and your answer to (i) above, calculate $E^{\circ}_{M^{2+}(aq)/M(s)}$ and $E^{\circ}_{N^{2+}(aq)/N(s)}$.

$\left(E^{\circ}_{L^{2+}(aq)/L(s)} = -0.80\ V\right)$

(iii) You are provided with the following arrangement, where a potentiometer (**P**) is connected between the metal rods **L** and **N**.



I. Calculate the potentiometer reading.

II. Write the electrode reactions that occur at each of the electrodes Ⓐ, Ⓑ, Ⓒ and Ⓓ separately when the potentiometer is removed and **L** and **N** are connected by a conductor.

(75 *marks*)

(*b*) The following questions are based on the element manganese (Mn).

(i) Write the complete electronic configuration of Mn.

(ii) Write **three** common oxidation states of Mn.

(iii) When $MnSO_4 \cdot H_2O$ is dissolved in water, solution **P** is obtained.

I. State the colour of solution **P**.

II. Give the chemical formula and the IUPAC name of the species responsible for this colour.

(iv) What would you observe when

I. dilute NaOH is added to solution **P**?

II. the mixture from (iv)(I) above is exposed to air?

III. conc. HCl is added to the mixture from (iv)(I) above?

(v) Give the chemical formulae of **five** oxides of Mn, and write the oxidation state of Mn in each. State the nature of each of the oxides as basic, weakly basic, amphoteric, weakly acidic, acidic.

(vi) Give the chemical formula of the most common oxoanion of Mn.

(vii) Give balanced ionic half equations to indicate how the oxoanion given by you in (vi) above behaves as an oxidizing agent in acidic and basic media.

(viii) State **one** use of $MnSO_4$ in the analysis of water quality parameters.

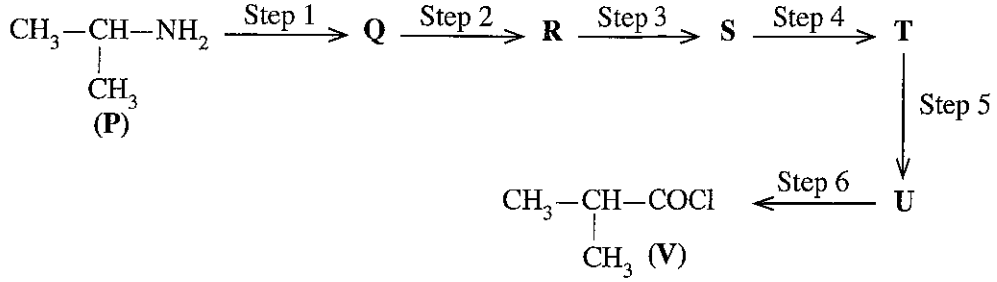
(75 *marks*)

[*see page twelve*

PART C — ESSAY

*Answer **two** questions only. (Each question carries **150** **marks.**)*

8. (*a*) Compound **P** was converted to compound **V** using the reaction scheme given below.



(i) Complete the above reaction sequence by drawing the structures of compounds **Q**, **R**, **S**, **T** and **U** and writing the reagents for steps 1–6 selected only from those given in the list below.

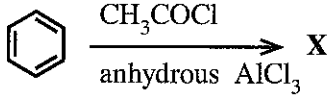
List of reagents
HCHO, Mg/dry ether, $H^+/K_2Cr_2O_7$, PCl_5, PBr_3, $NaNO_2$/dilute HCl, H^+/H_2O

(**Note:** The reaction of a compound with a Grignard reagent and the hydrolysis of the resultant magnesium alkoxide should be considered as **one step** in the above reaction sequence.)

(ii) Draw the structure of the product formed when compounds **P** and **V** react with each other. **(65 *marks*)**

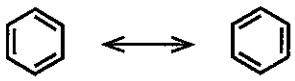
(*b*) (i) Propose a method to prepare a mixture of *o*-nitrobenzoic acid and *p*-nitrobenzoic acid from benzene using not more than **three** (03) steps.

(ii) Give the structure of the product **X** and the mechanism of the following reaction.



(65 *marks*)

(*c*) The structure of benzene is represented as the resonance hybrid of the following two hypothetical six membered cyclic structures (cyclohexatriene).



Using the standard enthalpy data of hydrogenation given below, show that benzene is more stable than hypothetical 'cyclohexatriene'.

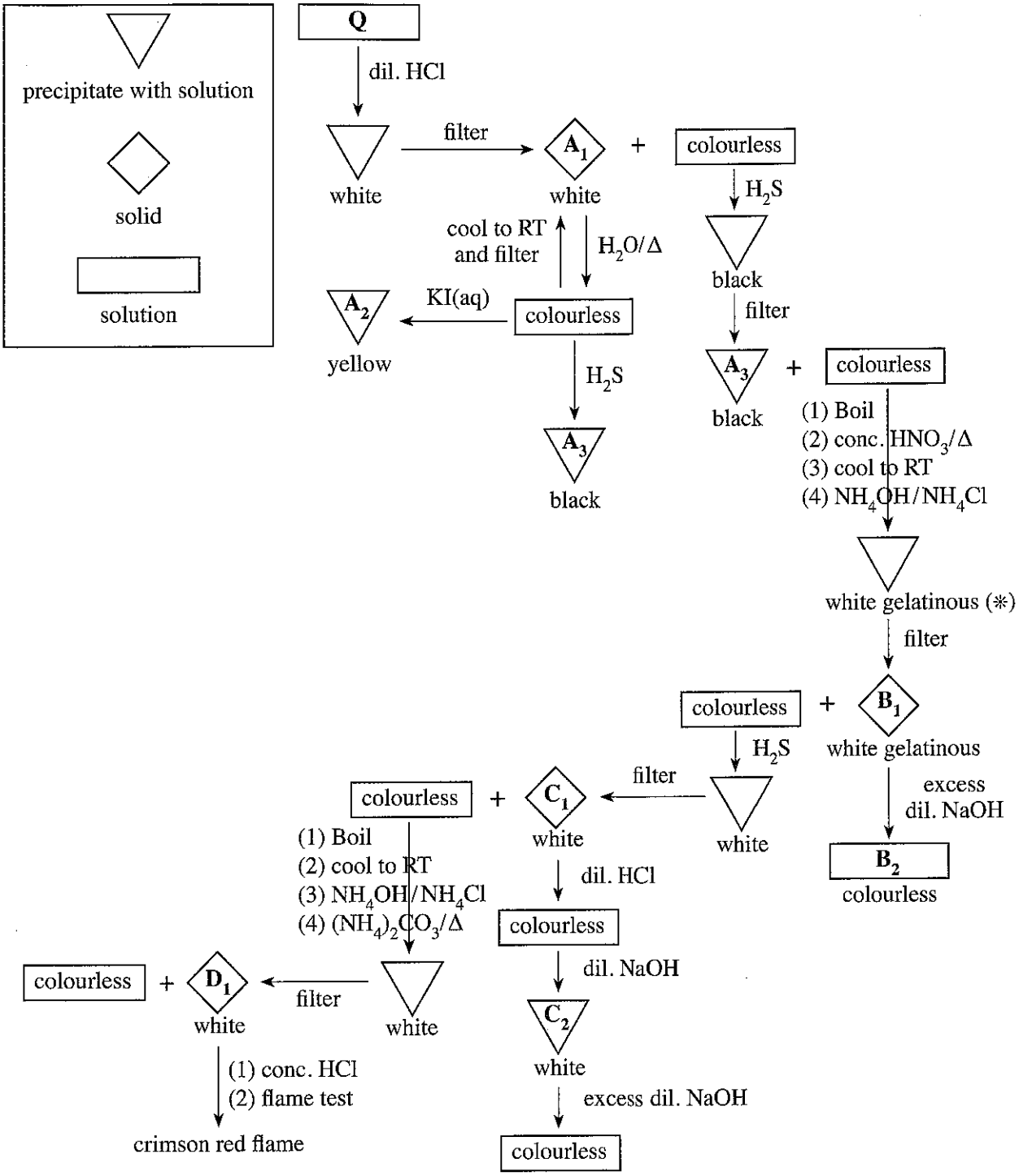
$\Delta H^\circ = -120$ kJ mol^{-1}

Benzene + $3\,H_2$ ⟶ cyclohexane $\Delta H^\circ = -208$ kJ mol^{-1}

(20 *marks*)

[*see page thirteen*

9. (*a*) The following question is based on the qualitative analysis of cations.
An aqueous solution **Q** contains **four** cations of metals **A**, **B**, **C** and **D**. **Q** is subjected to the reactions given in the scheme below.
The symbols given in the box are used to represent precipitates with solutions, solids and solutions.
(**Note**: RT – room temperature)



(i) A_1, A_2, A_3, B_1, B_2, C_1, C_2, and D_1 are compounds/species of the four cations **A**, **B**, **C**, and **D**. Identify A_1, A_2, A_3, B_1, B_2, C_1, C_2, and D_1.
(**Note**: Write **only** chemical formulae. Chemical equations and reasons are **not** required.)

(ii) Give a reason for the use of NH_4OH/NH_4Cl as a reagent when obtaining the white gelatinous precipitate (*). **(75 *marks*)**

[*see page fourteen*

(*b*) A mixture **X** contains only aluminium sulfide (Al_2S_3) and ferric sulfide (Fe_2S_3). The following procedure was carried out to calculate the mass percentages of Al_2S_3 and Fe_2S_3 in **X**.

When a mass **m** of mixture **X** was heated at high temperature under H_2 gas, Al_2S_3 remains unchanged but Fe_2S_3 was converted to iron (Fe) metal. The final mass obtained was 0.824 g.

When another mass **m** of mixture **X** was heated at high temperature in air, both Al_2S_3 and Fe_2S_3 decomposed, giving SO_2 gas. This SO_2 gas was bubbled through a solution of H_2O_2 and oxidized to H_2SO_4 acid, which is the only product. When this entire solution was titrated with a standard 1.00 mol dm^{-3} NaOH solution in the presence of phenolpthalein indicator, the burette reading was 36.00 cm^3.

(i) Write the balanced chemical equation for the reaction of Fe_2S_3 with hydrogen gas.

(ii) Write the balanced chemical equation for the reaction of SO_2 with H_2O_2 to give H_2SO_4.

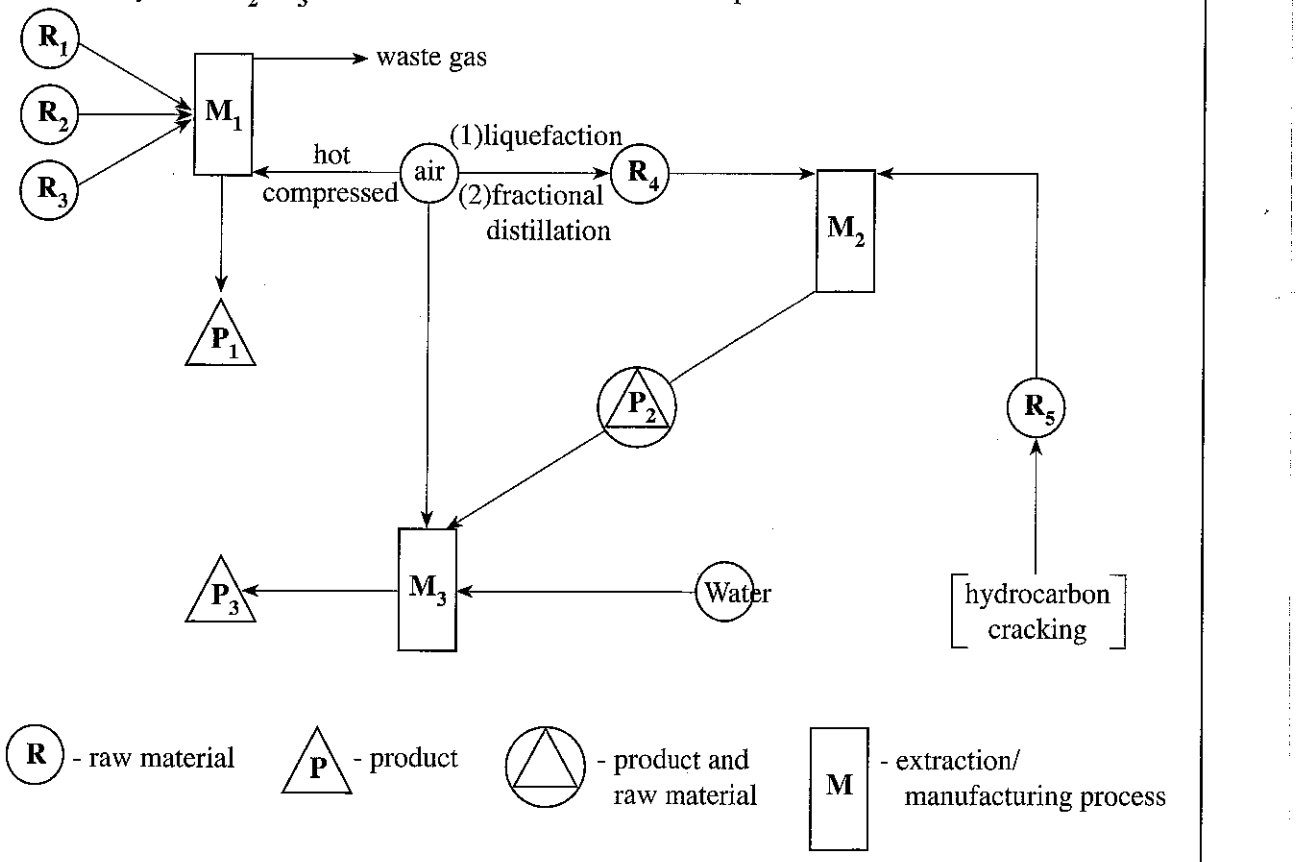
(iii) Calculate the mass percentages of Al_2S_3 and Fe_2S_3 in mixture **X**.

(iv) If the above titration is carried out using methyl orange as the indicator instead of phenolpthalein, would there be a change in the burette reading? Explain your answer.

(Relative atomic mass: Al=27, S=32, Fe=56) **(75 *marks*)**

10. (*a*) The following flow chart shows the industrial extraction/production of three important elements/ compounds $\mathbf{P_1}$, $\mathbf{P_2}$ and $\mathbf{P_3}$.

There is evidence to show that our ancestors produced $\mathbf{P_1}$ thousands of years ago. $\mathbf{P_1}$ is used as a catalyst in $\mathbf{M_2}$. $\mathbf{P_3}$ is used in the manufacture of explosives.



(i) Name the manufacturing processes $\mathbf{M_2}$ and $\mathbf{M_3}$. (e.g.: Manufacture of Na_2CO_3 is named as Solvay process.)

(ii) Identify the process $\mathbf{M_1}$ and name the main constituent of its waste gas.

(iii) Give the common names of the raw materials $\mathbf{R_1}$, $\mathbf{R_2}$ and $\mathbf{R_3}$ used in $\mathbf{M_1}$.

(**Note**: $\mathbf{R_1}$ functions as a reducing agent as well as an energy source in $\mathbf{M_1}$; $\mathbf{R_2}$ is a naturally occurring source which can be used to obtain $\mathbf{P_1}$.)

[*see page fifteen*

(iv) Write a balanced chemical equation for the role of $\mathbf{R}_1$ as a reducing agent in $\mathbf{M}_1$ process.

(v) Identify $\mathbf{R}_4$ and $\mathbf{R}_5$.

(vi) Give balanced chemical equations for reactions taking place in the processes $\mathbf{M}_1$, $\mathbf{M}_2$ and $\mathbf{M}_3$. Appropriate conditions (temperature, pressure, catalysts, etc.) must be stated as required. (**Note**: For the $\mathbf{M}_1$ process, give only the reactions showing the conversion of $\mathbf{R}_2$ to $\mathbf{P}_1$.)

(vii) Give **two** uses each of $\mathbf{P}_1$, $\mathbf{P}_2$ and $\mathbf{P}_3$ (**other than** what is indicated in the flow chart or given in the question).

(viii) State whether the $\mathbf{M}_2$ process would be favoured at very high temperatures. Explain your answer using ΔH, ΔS and ΔG.

(50 *marks*)

(b) The following questions are based on photochemical smog and water pollution.

(i) State the major types of gaseous chemical pollutants and conditions that are required for the formation of photochemical smog.

(ii) State why the strength of photochemical smog is low in the morning and evening.

(iii) Using balanced chemical equations, explain how ozone is formed in the lower atmosphere due to photochemical smog.

(iv) State **four** major products (excluding ozone) of photochemical smog.

(v) State **three** free radicals produced during the formation of photochemical smog.

(vi) Many countries now promote the use of electric vehicles. State how the use of electric vehicles affect the formation of photochemical smog.

(vii) State an environmental problem, other than photochemical smog, that could ease due to the use of electric vehicles.

(viii) A ship carrying the following chemicals sank in the sea.

Na_2HPO_4, HNO_3, $Pb(CH_3COO)_2$

State an effect from each chemical on the water quality parameters of the water surrounding the ship, by the release of the above chemicals.

(50 *marks*)

(c) The following questions are based on natural rubber and additives used for polymer related products.

(i) Sketch the repeating unit of natural rubber.

(ii) Give a compound that can be used to prevent coagulation of natural rubber latex.

(iii) State a compound that can be used to coagulate natural rubber latex and explain how it acts.

(iv) Briefly state how the 'vulcanization' of natural rubber is carried out.

(v) State **two** types of substances used to increase the efficiency of vulcanization.

(vi) Give **three** properties, which can be enhanced by adding additives to polymer products.

(50 *marks*)

* * *

[*see page sixteen*

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 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

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