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இலங்கைப் பரீட்சைத் திணைக்களம்
Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2018 අගෝස්තු
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தரப்) பரீட்சை, 2018 ஓகஸ்ற்
General Certificate of Education (Adv. Level) Examination, August 2018

15.08.2018 / 0830 – 1030

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 $R = 8.314\ \mathrm{J\ K^{-1}\ mol^{-1}}$
Avogadro constant $N_A = 6.022 \times 10^{23}\ \mathrm{mol^{-1}}$
Planck's constant $h = 6.626 \times 10^{-34}\ \mathrm{J\ s}$
Velocity of light $c = 3 \times 10^{8}\ \mathrm{m\ s^{-1}}$

1. The number of unpaired electrons present in a gaseous Co^{3+} ion in its ground state is,
(1) 1 (2) 2 (3) 3 (4) 4 (5) 5

2. Which quantum number(s) (n, l, m_l, m_s) is/are associated with the shape of an atomic orbital of an atom?
(1) l (2) m_l (3) n and l (4) n and m_l (5) l and m_l

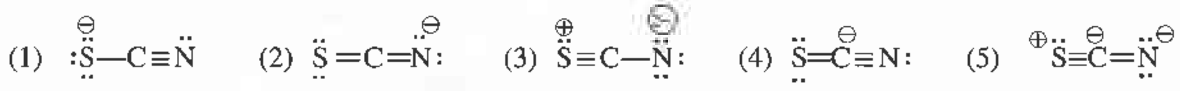
3. What is the IUPAC name of the compound shown below?

$$CH_3CH_2\underset{\displaystyle Br}{\underset{|}{C}H}-\underset{\displaystyle NO_2}{\underset{|}{C}}=CHCO_2H$$

(1) 4–bromo–3–nitro–2–hexenoicacid
(2) 4–bromo–3–nitro–2–hexenoic acid
(3) 3–nitro–4–bromo–2–hexenoicacid
(4) 3–nitro–4–bromo–2–hexenoic acid
(5) 3–bromo–4–nitro–4–hexenoic acid

4. The **correct** answer when the molecules O_2, H_2O, H_2O_2, OF_2 and O_2F_2 (structure similar to H_2O_2) are arranged in the **decreasing** order of the oxidation state of oxygen (O) is,
(1) $O_2F_2 > OF_2 > O_2 > H_2O > H_2O_2$
(2) $H_2O > H_2O_2 > O_2 > O_2F_2 > OF_2$
(3) $H_2O_2 > O_2F_2 > O_2 > OF_2 > H_2O$
(4) $OF_2 > O_2F_2 > O_2 > H_2O > H_2O_2$
(5) $OF_2 > O_2F_2 > O_2 > H_2O_2 > H_2O$

5. The **most** acceptable Lewis structure for the thiocyanate ion SCN^- is,



6. The molarity ($\mathrm{mol\ dm^{-3}}$) of a NaI solution which has a density of $1.03\ \mathrm{g\ cm^{-3}}$ and is 3% NaI by mass is,
(Na = 23, I = 127)
(1) 0.21 (2) 0.23 (3) 0.25 (4) 0.28 (5) 0.30

[*See page two*

7. Precipitates of AgI and AgBr were added to a small amount of distilled water. This mixture was allowed to reach equilibrium at 25 °C. It was observed that both the solids were present in the system at equilibrium. Which of the following relations is applicable to this solution?
($K_{sp(AgI)} = 8.0 \times 10^{-17}$ mol^2 dm^{-6}, $K_{sp(AgBr)} = 5.0 \times 10^{-13}$ mol^2 dm^{-6} at 25 °C)

(1) $[Br^-] = \sqrt{5.0 \times 10^{-13}}$ mol dm^{-3} and $[I^-] = \sqrt{8.0 \times 10^{-17}}$ mol dm^{-3}

(2) $[Br^-]\,[I^-] = [Ag^+]^2$

(3) $\left[Ag^+\right] = \left(\sqrt{5.0 \times 10^{-13}} + \sqrt{8.0 \times 10^{-17}}\right)$ mol dm^{-3}

(4) $\dfrac{[Br^-]}{[I^-]} = \dfrac{5.0}{8.0} \times 10^4$

(5) $[Ag^+] = [Br^-] = [I^-]$

8. Which of the following statements is **false**?
(1) Although the carbonates of all the group two metals in the Periodic Table are insoluble in water, their bicarbonates are soluble.
(2) The hydroxides of all the group two metals in the Periodic Table are soluble in water.
(3) The nitrates of all the group two metals in the Periodic Table are soluble in water.
(4) The oxides and hydroxides of Na and Mg show basic properties whereas the oxide and hydroxide of Al show amphoteric properties.
(5) The hydrides of Si and S show weakly acidic properties.

9. In which list are the elements given in the order of **increasing** (left to right) atomic radii?
(1) Li, Na, Mg, S (2) C, Si, S, Cl (3) B, C, N, P
(4) Li, Na, K, Ca (5) B, Be, Na, K

10. Liquids A and B form an ideal solution. Consider a mixture of liquids A and B in equilibrium with the vapour in a closed rigid container at constant temperature. P_A^o and P_B^o respectively are the saturated vapour pressures of A and B while P is the total pressure of the container and X_A^g is the mole fraction of A in the vapour phase. Which of the following is correct about this system?

(1) $P = \left(P_A^o - P_B^o\right) X_A^g + P_B^o$ (2) $\dfrac{1}{P} = \left(\dfrac{1}{P_A^o} - \dfrac{1}{P_B^o}\right) X_A^g + \dfrac{1}{P_B^o}$

(3) $P = \left(P_A^o + P_B^o\right) X_A^g - P_B^o$ (4) $\dfrac{1}{P} = \left(\dfrac{1}{P_B^o} - \dfrac{1}{P_A^o}\right) \dfrac{1}{X_A^g}$

(5) $\dfrac{1}{P} = \left(\dfrac{1}{P_A^o} - \dfrac{1}{P_B^o}\right) \dfrac{1}{X_A^g}$

11. The **increasing** order of boiling points of the following substances is,
He, CH_4, CCl_4, CBr_4, SiH_4
(1) $CH_4 < He < SiH_4 < CCl_4 < CBr_4$ (2) $He < SiH_4 < CH_4 < CCl_4 < CBr_4$
(3) $He < CH_4 < SiH_4 < CCl_4 < CBr_4$ (4) $CH_4 < He < SiH_4 < CBr_4 < CCl_4$
(5) $He < CH_4 < CCl_4 < SiH_4 < CBr_4$

12. Identify the **correct** statement from the following.
(1) Among the electronic transitions $n=2 \longrightarrow n=1$, $n=3 \longrightarrow n=2$ and $n=4 \longrightarrow n=3$ in a hydrogen atom, most energy is released in $n=3 \longrightarrow n=2$.
(2) Among the species OF_2, OF_4 and SF_4, the least stable is SF_4.
(3) Among the elements Li, C, N, Na and P, the least electronegative element is Li.
(4) In the following pairs (Li & F), (Li^+ & F^-), (Li^+ & O^{2-}) and (O^{2-} & F^-), the difference in radii is greatest between Li^+ and O^{2-}.
(5) The only type of intermolecular force present in CH_2Cl_2 in the liquid phase is dipole-dipole forces.

[*See page three*

13. Consider the reaction: $CH_4(g) \longrightarrow CH_3(g) + H(g)$

The standard change in enthalpy of the above reaction is,

(1) the standard enthalpy change for the dissociation of the first C—H bond in methane.
(2) the standard atomisation enthalpy change of methane.
(3) the standard first ionisation enthalpy change of methane.
(4) the standard bond dissociation enthalpy change of methane.
(5) the standard radical formation enthalpy change of methane.

14. The elementary reaction $2A(g) \longrightarrow B(g)$ occurs in a closed rigid container at a constant temperature. Initial pressure of the container is P_o and the pressure when the rate of reaction is 50% of the initial value is P_t. Which of the following gives the correct value for $\frac{P_t}{P_o}$?

(1) $\frac{P_t}{P_o} = \frac{1}{2}$ (2) $\frac{P_t}{P_o} = \frac{1}{\sqrt{2}}$ (3) $\frac{P_t}{P_o} = \frac{1+\sqrt{2}}{2\sqrt{2}}$ (4) $\frac{P_t}{P_o} = \frac{\sqrt{2}}{1+\sqrt{2}}$ (5) $\frac{P_t}{P_o} = \frac{\sqrt{2}-1}{1+\sqrt{2}}$

15. An equimolar aqueous solution of the weak acids HA and HB (1.0 mol dm^{-3} in each acid) with pK_a values 4.7 and 5.0 respectively is at equilibrium. The value of log $\left(\frac{[A^-]}{[B^-]}\right)$ is approximately equal to,

(1) 23.5 (2) −0.3 (3) 0.3 (4) 0.94 (5) 1.06

16. Which of the following statements about C_6H_5OH is **false**?

(1) Reacts with CH_3COCl to form a phenyl ester.
(2) Reacts with bromine water to give a white precipitate.
(3) Evolves CO_2 gas when treated with $NaHCO_3$.
(4) Gives a coloured compound when treated with $C_6H_5N_2^+Cl^-$ in the presence of NaOH.
(5) Gives a coloured (purplish) solution when treated with neutral $FeCl_3$.

17. The half life of a reaction is,

(1) always independent of the initial concentration of reactants.
(2) always dependent on the rate constant.
(3) always independent of the order of the reaction.
(4) always independent of temperature.
(5) equal to twice the total reaction time.

18. Electromotive force of an electrochemical cell does **not** depend on,

(1) the nature of the electrolytes.
(2) temperature.
(3) the concentrations of the electrolytes.
(4) the surface areas of the electrodes.
(5) the types of metals that form the electrodes.

19. IO_3^- (iodate ion) oxidizes the SO_3^{2-} ion to SO_4^{2-} in acidic medium. The mass of KIO_3 required to totally oxidize the amount of Na_2SO_3 present in 25.0 cm^3 of a solution of Na_2SO_3 (0.50 mol dm^{-3}) to Na_2SO_4 is 1.07 g. (O = 16, K = 39, I = 127)

The final oxidation state of iodine after the completion of the reaction is,

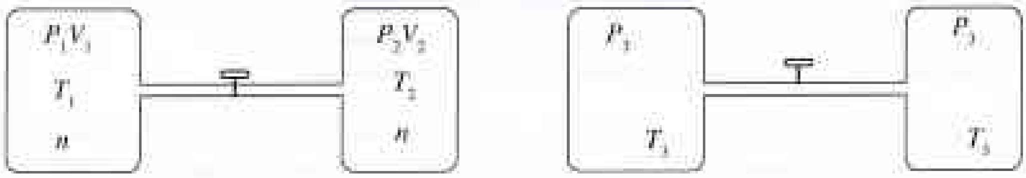
(1) −1 (2) 0 (3) +1 (4) +2 (5) +3

20. Which of the following statements is **false** with regard to the *s*-block elements in the Periodic Table?

(1) All elements in group I react with water liberating H_2 gas.
(2) All elements in group I except Li react with N_2 gas.
(3) All elements in group II react with N_2 gas.
(4) Na reacts with excess O_2 to give Na_2O_2 whereas K gives KO_2.
(5) All elements in the *s*-block are good reducing agents.

[*See page four*

21. A system consisting of two rigid containers containing an ideal gas is shown in the diagram. The containers can be connected to each other by opening the tap. The system changes from configuration **A** to configuration **B** when the tap is opened. In general n, P, V and T represent number of moles, pressure, volume and temperature respectively.



configuration **A** (tap closed) configuration **B** (tap opened)

Which of the following relations is **correct** about this system?

(1) $P_1V_1 = P_2V_2$ (2) $\frac{P_3T_1}{P_1} + \frac{P_3T_2}{P_2} = 2T_3$ (3) $\frac{T_1}{P_1} = \frac{T_2}{P_2}$

(4) $P_1T_1 = P_2T_2$ (5) $P_1V_1 + P_2V_2 = P_3(V_1 + V_2)$

22. Which of the following statements is **false** with regard to $3d$-elements of the Periodic Table?

(1) Atomic radii are smaller than the atomic radii of the s-block elements in the same period.
(2) Densities are higher than the densities of the s-block elements in the same period.
(3) V_2O_5, CrO_3 and Mn_2O_7 are acidic oxides.
(4) First ionization energies are less than the first ionization energies of the s-block elements in the same period.
(5) The most common oxidation states of cobalt in cobalt compounds are +2 and +3.

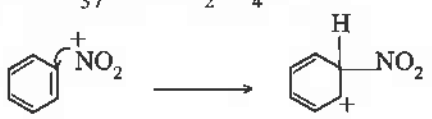
23. Standard Gibbs energy changes for the reaction, $MO(s) \rightarrow M(s) + \frac{1}{2}O_2(g)$ at two different temperatures are given below.

T/K	$\Delta G°$/kJ mol^{-1}
1000	–100.2
2000	–148.6

The standard entropy change of the reaction is,

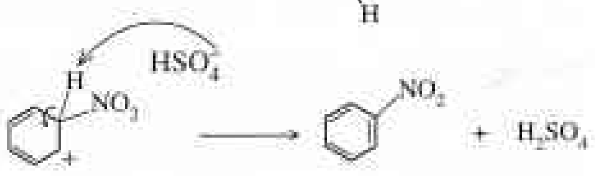
(1) 248.8 J K^{-1} mol^{-1} (2) –248.8 J K^{-1} mol^{-1} (3) –48.4 J K^{-1} mol^{-1}
(4) 348.4 J K^{-1} mol^{-1} (5) 48.4 J K^{-1} mol^{-1}

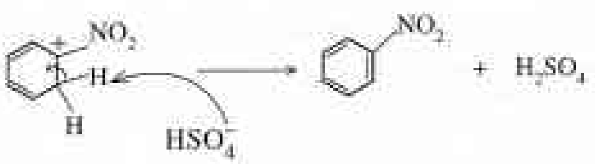
24. Which of the following represents a **correct** step in the mechanism of nitration of benzene with conc. HNO_3 / conc. H_2SO_4?

(1) 

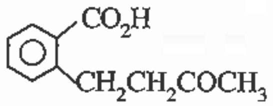
(2) 

(3) 

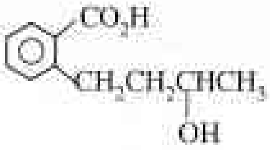
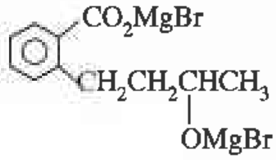
(4) 

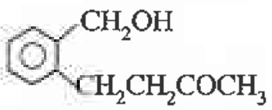
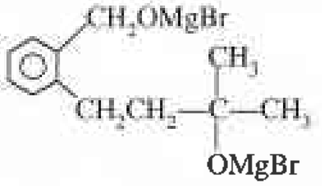
(5) 

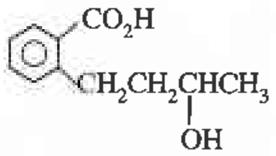
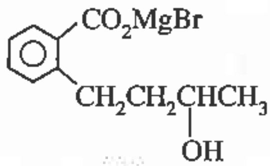
[*See page five*

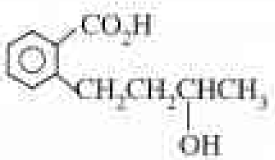
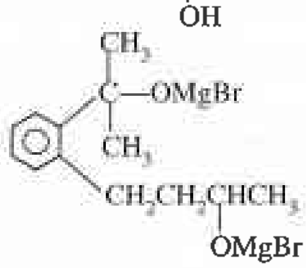
25.  $\xrightarrow[(2)\ H^+/H_2O]{(1)\ NaBH_4}$ **X** $\xrightarrow[CH_3MgBr]{excess}$ **Y**

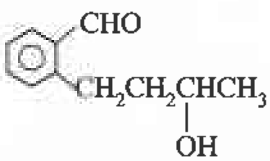
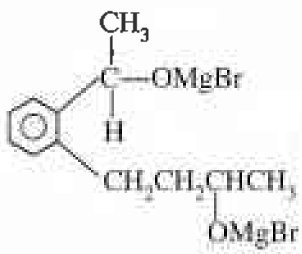
In the reaction sequence given above, the structures of **X** and **Y** respectively are,

(1)  , 

(2)  , 

(3)  , 

(4)  , 

(5)  , 

26. When $(NH_4)_2CO_3(s)$, $(NH_4)_2Cr_2O_7(s)$ and $NH_4NO_3(s)$ are heated, the nitrogen containing compounds obtained are respectively,

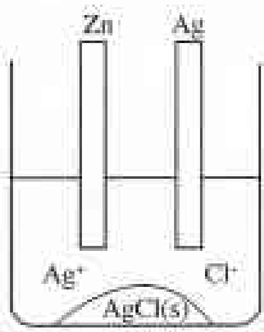
(1) NH_3, N_2 and NO_2
(2) N_2O, N_2 and NH_3
(3) NH_3, N_2 and N_2O
(4) N_2, N_2O and NH_3
(5) N_2, NH_3 and N_2O

27. Which of the following would occur soon after connecting a rod of Zn and a rod of Ag immersed in a saturated solution of AgCl and AgCl(s) kept in a beaker as shown in the diagram, by a conductor?

$Zn^{2+}(aq) + e \longrightarrow Zn(s)\ \ E^\circ = -0.76\ V$

$Ag^{+}(aq) + e \longrightarrow Ag(s)\ \ E^\circ = 0.80\ V$

(1) Zn dissolves, Ag deposits, AgCl(s) dissolves.
(2) Zn dissolves, Ag dissolves, AgCl(s) dissolves.
(3) Zn dissolves, Ag dissolves, AgCl(s) deposits.
(4) Zn deposits, Ag dissolves, AgCl(s) dissolves.
(5) Chloride concentration in the solution decreases.



28. In the reaction sequence given below, the structures of **P** and **Q** respectively are,

$$C_6H_5C\equiv CH \xrightarrow{Hg^{2+}/\text{dil. } H_2SO_4} \mathbf{P} \xrightarrow[\text{conc. HCl}]{Zn/Hg} \mathbf{Q}$$

(1) $C_6H_5C(OH)=CH_2$, $C_6H_5CH=CH_2$

(2) $C_6H_5CH=CH(OH)$, $C_6H_5CH=CH_2$

(3) $C_6H_5-C(=O)-CH_3$, $C_6H_5-CH(OH)-CH_3$

(4) $C_6H_5-C(=O)-CH_3$, $C_6H_5CH_2CH_3$

(5) $C_6H_5C(OH)=CH_2$, $C_6H_5CH(OH)CH_3$

29. Which of the following statements is **incorrect** regarding polymers?
(1) Bakelite is a thermosetting polymer.
(2) Teflon is a thermoplastic polymer.
(3) Nylon 6,6 is formed by addition polymerisation between 1,6–diaminohexane and hexanedioic acid.
(4) Terelene is formed by condensation polymerisation between ethylene glycol and terephthalic acid.
(5) Natural rubber consists of *cis*-polyisoprene chains.

30. An experiment was carried out to find the order (m) with respect to $S_2O_3^{2-}$ of the reaction $S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow H_2O(l) + SO_2(g) + S(s)$. Initial rate of the reaction (R) was measured by adding different volumes (v) of 0.01 mol dm^{-3} $S_2O_3^{2-}$ into a solution of an acid. The H^+ concentration of the reaction mixture was kept constant, but the total volume (V) was allowed to vary. Which of the following relations regarding the initial rate of the reaction is correct?

(1) $R \propto \left(\frac{v}{V}\right)^m$ (2) $R \propto v^m$ (3) $R \propto v^{\frac{1}{m}}$ (4) $R \propto \left(\frac{v}{V}\right)^{\frac{1}{m}}$ (5) $R \propto V^m$

- 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. Consider a titration between a weak acid (fixed volume) and a strong base. Which of the following is/are independent of the weak acid concentration?
(*a*) pH at the equivalence point.
(*b*) Volume of the strong base required to reach the end point.
(*c*) Dissociation constant of the weak acid.
(*d*) Value of $[H^+] \times [OH^-]$ of the solution in the titration flask.

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

$$\underset{\mathbf{a}}{CH_3}-\underset{\mathbf{b}}{C}\equiv\underset{\mathbf{c}}{C}-\underset{\mathbf{d}}{C}HO$$

(*a*) All four carbon atoms lie in the same plane.
(*b*) The angle between $C_{\mathbf{d}}-H$ and the $C_{\mathbf{d}}-C_{\mathbf{c}}$ bonds is approximately 120°.
(*c*) Between $C_{\mathbf{b}}$ and $C_{\mathbf{c}}$, there are two σ-bonds and one π-bond.
(*d*) Between $C_{\mathbf{b}}$ and $C_{\mathbf{c}}$, there is one σ-bond and two π-bonds.

33. Which of the following statement/s is/are **true** with regard to the manufacture of Na_2CO_3?
(*a*) CO_2 is one of the raw materials used.
(*b*) The reaction between CO_2 and aqueous NaCl saturated with NH_3 is endothermic.
(*c*) The manufacturing process involves five stages.
(*d*) Most of the NH_3 used in the process can be recovered.

34. Temperature must be maintained at a constant value during the experimental determination of the order of an elementary reaction, because,
(*a*) the order of the reaction depends on temperature.
(*b*) the activation energy changes with temperature.
(*c*) the mechanism of the reaction changes with temperature.
(*d*) the rate constant changes with temperature.

35. Which of the following statement/s is/are **true** regarding ethene and ethyne?
(*a*) CaC_2 reacts with water to form ethyne.
(*b*) CaC_2 reacts with water to form ethene.
(*c*) Ethene reacts with ammoniacal $AgNO_3$ to give a precipitate.
(*d*) Ethyne reacts with ammoniacal Cu_2Cl_2 to give a precipitate.

36. Which of the following statement/s is/are **true** with regard to halogens?
(*a*) The boiling points of halogens increase down the group.
(*b*) Unlike other halogens, fluorine always has an oxidation state of (–1) except in F_2.
(*c*) All halogens are good reducing agents.
(*d*) Although fluorine is the most reactive of all the elements in the Periodic Table, it does not react with inert gases.

37. For the reaction $C(s)+CO_2(g) \rightleftharpoons 2CO(g)$ occurring in a closed rigid container, percentage yields of CO(g) at 700 °C and 800 °C are 60% and 80% respectively. Which of the following statement/s is/are **correct** regarding the above reaction?
(*a*) The reaction is endothermic.
(*b*) The reaction is exothermic.
(*c*) Reverse reaction is favoured by decreasing the temperature.
(*d*) Equilibrium can be shifted towards the reactants by removing C(s).

38. Cyclopropane $\longrightarrow$ propene is an elementary reaction.
Which of the following statement/s is/are **correct** regarding the above reaction?
(*a*) Half life of the reaction depends on cyclopropane concentration.
(*b*) Rate of the reaction does not depend on propene concentration.
(*c*) The fraction of cyclopropane molecules having energy greater than the activation energy increases with increasing temperature.
(*d*) Reaction occurs *via* a bimolecular collision (molecularity = 2).

39. Which of the following statement/s is/are **true** regarding 3–hexene?
(*a*) Does not show geometric isomerism.
(*b*) Shows optical isomerism.
(*c*) The compound obtained when reacted with H_2/Pd does not show optical isomerism.
(*d*) The compound obtained when reacted with HBr shows optical isomerism.

[See page eight

40. Which of the following statements is/are **correct** with regard to the nitrogen cycle?
(*a*) N_2 in the atmosphere is fixed only by atmospheric and industrial fixation.
(*b*) N_2 is reduced during atmospheric fixation.
(*c*) N_2 is oxidized during industrial fixation.
(*d*) Nitrates and nitrites formed during atmospheric fixation are utilized by plants to make proteins when the rainfall deposit them on the ground.

- 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.	$BaCO_3$ is more thermally stable than $MgCO_3$.	Polarizing power of group two cations decreases down the group.
42.	The lone pair of electrons on nitrogen in an amine has a lower tendency to form a bond with H^+, than the lone pair of electrons on oxygen in an alcohol.	Nitrogen is less electronegative than oxygen.
43.	A reaction at equilibrium can be driven forward (i.e. shift of equilibrium point to the right) by adding a catalyst.	The catalyst provides a pathway with a low activation energy only to the forward reaction.
44.	CO_3^{2-} and SO_3^{2-} ions have similar shapes.	Central atoms of both CO_3^{2-} and SO_3^{2-} have lone pairs of electrons.
45.	The boiling point of $CH_3CH_2CH_2OH$ is higher than the boiling points of CH_3CH_2CHO and CH_3COCH_3.	The carbon oxygen double bond is stronger than the carbon oxygen single bond.
46.	A reaction occurring spontaneously in an **isolated** system **always** has a negative Gibbs energy change.	A process in an **isolated** system cannot be changed from outside.
47.	Commonly used soap contain the sodium or potassium salts of fatty acids formed by the reaction of NaOH or KOH with oils and fats.	The reaction of an ester with aqueous NaOH or KOH gives the sodium or potassium salt of the carboxylic acid and the alcohol.
48.	C_6H_5Br does not react easily with NaOH to form C_6H_5OH.	The phenyl carbocation is very stable.
49.	When an aqueous solution of a weak acid is diluted, both the fraction of dissociated acid molecules and pH of the medium are increased.	Dissociation of weak acid molecules occur in such a way that the acid dissociation constant K_a remains constant.
50.	In the presence of sunlight CO_2 is fixed in green plants.	Increase of CO_2 level in the atmosphere cannot be controlled by green plants.

* * *

[*See page nine*

The Periodic Table

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

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

ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව
இலங்கைப் பரீட்சைத் திணைக்களம்
Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2018 අගෝස්තු
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2018 ஓகஸ்ற்
General Certificate of Education (Adv. Level) Examination, August 2018

රසායන විද්‍යාව II
இரசாயனவியல் II
Chemistry II

02 E II

17.08.2018 / 0830 - 1140

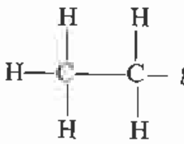
පැය තුනයි
மூன்று மணித்தியாலம்
Three hours

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,* $R = 8.314\ \mathrm{J\,K^{-1}\,mol^{-1}}$
* *Avogadro constant,* $N_A = 6.022 \times 10^{23}\ \mathrm{mol^{-1}}$
* **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 2 - 8)

* *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 9 - 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		
Percentage		

Final Mark

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 **10** marks.)*

Do not write in this column.

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

(i) The polarizability of halide ions increases with increasing size. ....

(ii) The O—N—O bond angle of NO_2 is greater than that of NO_2^-. ....

(iii) London dispersion forces among CCl_4 molecules are smaller than the London dispersion forces among SO_3 molecules. ....

(iv) The shape of the HSO_4^- ion is trigonal bipyramidal. ....

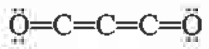
(v) All 3*d* atomic orbitals of an atom are represented by quantum numbers (n, l, m_l) 3, 2, 1. ....

(vi) The addition of an electron to a gaseous phosphorus atom is an exothermic process whereas for a gaseous nitrogen atom it is endothermic. ....

(2.4 marks)

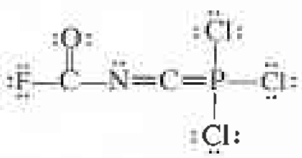
(*b*) (i) Draw the **most** acceptable Lewis structure for the molecule SF_3N.

(ii) The most stable Lewis structure for the molecule C_3O_2 (carbon suboxide) is shown below. Draw another **two** Lewis structures (resonance structures) for this molecule.
(Note: Marks will not be awarded for Lewis structures drawn with octet rule violated.)

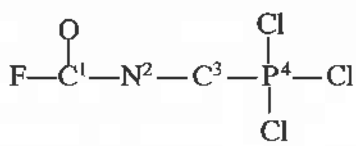


(iii) Based on the Lewis structure given below, state the following regarding the C, N and P atoms given in the table below.

I. VSEPR pairs around the atom II. electron pair geometry around the atom
III. shape around the atom IV. hybridization of the atom



The atoms are numbered as follows:



		C^1	N^2	C^3	P^4
I.	VSEPR pairs				
II.	electron pair geometry				
III.	shape				
IV.	hybridization				

[see page three

Do not write in this column.

5639

(iv) Identify the atomic/hybrid orbitals involved in the formation of the following σ bonds in the Lewis structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

I. $F—C^1$ F.............................. C^1 ....

II. $C^1—N^2$ C^1.............................. N^2 ....

III. $N^2—C^3$ N^2.............................. C^3 ....

IV. $C^3—P^4$ C^3.............................. P^4 ....

V. $P^4—Cl$ P^4.............................. Cl ....

(v) Identify the atomic orbitals involved in the formation of the following π bonds in the Lewis structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

I. $N^2—C^3$ N^2.............................. C^3 ....

II. $C^3—P^4$ C^3.............................. P^4 .... *(5.2 marks)*

(c) Arrange the following in the **increasing** order of the property indicated in parenthesis. (Reasons are **not** required.)

(i) B, Na, P, Be, N (first ionization energy)

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

(ii) NH_3, NOCl, NO_2Cl, NH_4^+, $F_3C—NC$ (electronegativity of nitrogen)

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

(iii) Quantum numbers of electrons in an atom (n, l, m_l, m_s)

$\left(3, 1, 0, -\frac{1}{2}\right), \left(3, 0, 0, +\frac{1}{2}\right), \left(2, 0, 0, +\frac{1}{2}\right), \left(2, 1, +1, +\frac{1}{2}\right), \left(3, 2, -1, +\frac{1}{2}\right)$ (energy of electron)

.... < .... < .... < .... < .... *(2.4 marks)*

100

2. (a) **X** is a *p*-block element in the Periodic Table. It exists as a diatomic gas. **X** exhibits a wide range of oxidation states. **Y** is the most common hydride of **X**. **Y** dissolves readily in water to give a basic solution. **Y** acts as an oxidizing agent, a reducing agent, an acid and a base. The diatomic gas of **X** is used in the manufacture of **Y**.

(i) Identify **X** and **Y**.

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

(ii) The diatomic gas of **X** is generally considered as inert. Briefly explain.

....

....

....

(iii) Write the chemical formulae of **three** oxides of **X**, and indicate the oxidation state of **X** in each compound.

....

....

....

(iv) In each of the following instances, give a balanced chemical equation to indicate the action of **Y**.

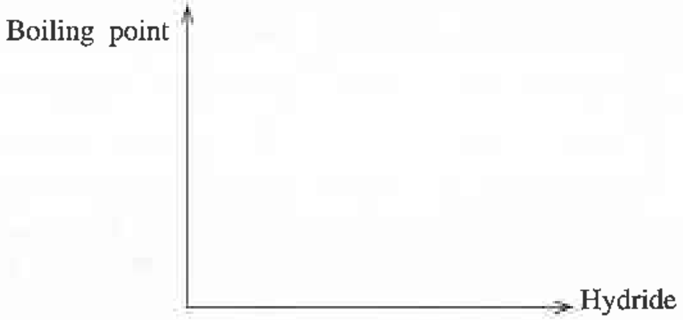
I. **Y** as an oxidizing agent ....

II. **Y** as a reducing agent ....

[see page four

Do not write in this column

(v) Consider the hydrides of the elements in the group to which **X** belongs, which are analogous to **Y**. Sketch the variation in boiling points of these hydrides (including **Y**) in the graph below. In your sketch indicate the hydrides using their chemical formulae. (**Note**: Values of boiling points are **not** required.)



(vi) Give reasons for the variation in boiling points in part (v) above.

....

....

....

....

....

(vii) I. Write what you would observe when an excess of an aqueous solution of **Y** is added to a solution of $Al_2(SO_4)_3$.

....

II. Write the chemical formula of the species that gives rise to your observation in part I above.

....

(viii) Give **one chemical** test to identify **Y**.

Test : ....

Observation : ....

(ix) **Z** is an oxo-acid of **X** and a strong oxidizing agent.

I. Identify **Z**. ....

II. State the products obtained when hot concentrated **Z** reacts with sulphur.

....

(6.0 *marks*)

(*b*) **A** and **B** are compounds of two *p*-block elements that belong to the same group in the Periodic Table. **A** exists as a colourless, odourless liquid at room temperature and atmospheric pressure. It is also found in the gaseous and solid states. The solid state of **A** is less dense than its liquid state. Ionic and polar compounds are readily soluble in **A**.

B is a colourless gas at room temperature and atmospheric pressure. A filter paper moistened with lead acetate turns black on treatment with **B**.

(i) Identify **A** and **B**.

A = ... **B** = ...

(ii) Sketch the shapes of **A** and **B** showing lone pairs of electrons where necessary.

[see page five

Do not write in this column.

(iii) Giving reasons, state whether **A** or **B** has the larger bond angle.

....

....

....

(iv) In each of the following instances, give a balanced chemical equation to indicate the action of **A**.

I. **A** as an acid: ....

II. **A** as a base: ....

(v) Write the balanced chemical equation for the reaction of **B** with aqueous lead acetate.

....

(vi) I. Write what you would observe when **A** and **B** are added **separately** to an acidified solution of $BiCl_3$.

with **A** (excess): .... with **B**: ....

II. Write balanced chemical equations for your observations in part I above.

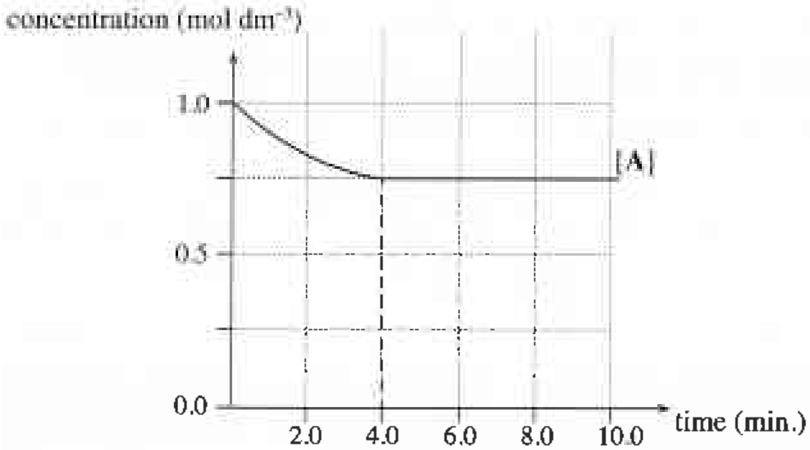
....

....

(4.0 *marks*)

100

3. The reaction **A** + **B** $\rightleftharpoons$ 2**C** + **D** (elementary in both directions) was carried out at 25 °C. Initially, the reaction mixture was made by dissolving 0.10 mol of **A** and 0.10 mol of **B** in distilled water (total volume 100.00 cm³). Variation in the concentration of **A** in this solution with time is shown in the graph.



(i) Calculate the amount of **A** (in moles) reacted during the first 4.0 minutes of the reaction.

....

....

....

(ii) Would the rate of the forward reaction be less than the rate of the reverse reaction after 4.0 minutes? Explain your answer.

....

....

....

[see page six

Do not write in this column.

(iii) Given that the rate constant of the forward reaction ($k_{forward}$) is 18.57 $mol^{-1}\,dm^3\,min^{-1}$, calculate the initial rate of the forward reaction.

(iv) Calculate the concentrations of **C** and **D** at equilibrium.
Draw the relevant curves showing the variation of the concentrations of **C** and **D** with time in the above graph and **label** them.

(v) Write the expression for the equilibrium constant K_c of the above reaction and calculate its value.

(vi) Calculate the value of the rate constant ($k_{reverse}$) of the reverse reaction.

(vii) After reaching equilibrium, the volume of the solution was doubled by adding 100.00 cm^3 of distilled water. Predict the direction of the net reaction soon after doubling the volume of the solution, by means of a suitable calculation.

[see page seven

Do not write in this column.

(viii) Consider that the above experiment was conducted at a temperature lower than 25 °C. How would this affect the rate of the reverse reaction? Explain your answer giving reasons.

....

....

....

(10.0 *marks*)

100

4. (*a*) (i) Compounds **A**, **B** and **C** are structural isomers of each other having the molecular formula $C_5H_{10}O$. All three compounds give yellow-orange precipitates with 2, 4−DNP. None of them give a silver mirror in the silver mirror test. When **A**, **B** and **C** were separately reacted with $NaBH_4$, compounds **D**, **E** and **F** respectively were obtained. Only **E** and **F** showed optical isomerism. When **B** and **C** were separately reacted with $CH_3CH_2CH_2MgBr$ followed by hydrolysis, compounds **G** and **H** respectively, were obtained. Only **G** showed optical isomerism. Draw the structures of **A, B, C, D, E, F, G** and **H** in the boxes given below. (It is **not** necessary to show stereoisomeric forms.)

A	**B**	**C**
D	**E**	**F**
G	**H**	

(ii) Draw the structure of the product of the following reaction.

$$\mathbf{A} \xrightarrow[\text{(2) dehydration}]{\text{(1) 2, 4–DNP}} \boxed{}$$

(4.5 *marks*)

[see page eight

Do not write in this column

(*b*) Draw the structure of the **major** organic **product** in each of the following reactions.

(i) $C_6H_6 \xrightarrow[150\ °C]{H_2/\text{Raney Ni}}$

(ii) $C_6H_5-NH_2 \xrightarrow{Br_2\ \text{water}}$

(iii) $CH_3CHO \xrightarrow[(2)\ \text{dehydration}]{(1)\ \text{aqueous NaOH}}$

(iv) $C_6H_5-\overset{\oplus}{N_2}\overset{\ominus}{Cl} \xrightarrow[\Delta]{H_3PO_2}$

(v) $C_2H_5CONH_2 \xrightarrow[\Delta]{\text{aqueous NaOH}}$

(vi) $CH_3CH{=}CH_2 \xrightarrow{\text{conc. } H_2SO_4}$

(vii) $CH_3COCl \xrightarrow{NH_3}$

(viii) $C_2H_5CO_2H \xrightarrow{PCl_5}$

(ix) $C_2H_5OH \xrightarrow{H^+/KMnO_4}$

(x) $C_2H_5COCH_3 \xrightarrow{HCN}$

(3.5 *marks*)

(*c*) One of the products in the reaction of Cl_2 with CH_4 in the presence of light is CH_3Cl. Write the steps of the mechanism of the reaction which shows how CH_3Cl is formed. Indicate movement of electrons using curved arrows / curved half arrows (↷/↷).

100

(2.0 *marks*)

[see page nine

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இலங்கைப் பரீட்சைத் திணைக்களம்
Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2018 අගෝස්තු
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2018 ஓகஸ்ர்
General Certificate of Education (Adv. Level) Examination, August 2018

රසායන විද්‍යාව II
இரசாயனவியல் II
Chemistry II

02 E II

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

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

PART B — ESSAY

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

5. (*a*) Consider the following reactions.

$$M(CO_3)_2{\cdot}nH_2O(s) \rightarrow M(CO_3)_2(s) + nH_2O(g)$$

$$M(CO_3)_2(s) \rightleftharpoons MO_2(s) + 2CO_2(g)$$

A small amount (0.10 mol) of $M(CO_3)_2{\cdot}nH_2O(s)$ is present in an evacuated rigid container of volume 0.08314 m^3. The temperature of the container was raised to 400 K. The metal carbonate, $M(CO_3)_2$ does not decompose at this temperature but the crystalline water evaporates completely. The pressure of the container was measured to be 1.60×10^4 Pa. Volume occupied by the solids is negligible.

Determine the value of 'n' in the formula $M(CO_3)_2{\cdot}nH_2O(s)$.

(2.0 *marks*)

(*b*) The temperature of the above system was then increased to 800 K. It was observed that some amount of the solid metal carbonate is decomposed and is in equilibrium with the gas phase. The pressure of the container was measured to be 4.20×10^4 Pa.

(i) Calculate the partial pressure of water vapour in the container at 800 K.

(ii) Calculate the partial pressure of CO_2 in the container at 800 K.

(iii) Write an expression for the pressure equilibrium constant, K_p for the decomposition of $M(CO_3)_2(s)$. Calculate K_p at 800 K.

(iv) Calculate the molar percentage of the metal carbonate decomposed at 800 K.

(v) Enthalpy change (ΔH) for the decomposition of the metal carbonate under the above conditions is 40.0 kJ mol^{-1}. Calculate the corresponding entropy change (ΔS).

(vi) Suggest **two** ways to drive the decomposition reaction of $M(CO_3)_2(s)$ in the forward direction.

(6.5 *marks*)

(*c*) With the aid of thermochemical cycles and the data given in the table, answer the following questions.

Species	Standard enthalpy of formation (ΔH_f°) (kJ mol^{-1})
M(s)	0.0
M(g)	800.0
O_2(g)	0.0
O(g)	249.2
MO_2(g)	–400.0

[see page ten

(i) Given that $MO(g) + \frac{1}{2} O_2(g) \rightarrow MO_2(g)$ $\Delta H^\circ = -50.0$ kJ mol^{-1}, calculate the standard enthalpy of formation of MO(g).

(ii) Calculate M–O bond dissociation enthalpy in MO(g).

(iii) Calculate M–O bond dissociation enthalpy in $MO_2(g)$.

(iv) By means of a suitable calculation, predict whether the reaction, $MO_2(g) \rightarrow MO(g) + \frac{1}{2} O_2(g)$ is spontaneous under standard conditions and 2000 K. Standard entropy change of this reaction is 30.0 J K^{-1} mol^{-1}.

(6.5 *marks*)

6. (*a*) An experiment was carried out to determine the partition coefficient of iodine (I_2) between water (**A**) and an organic solvent (**B**) which form an immiscible liquid system.

20.00 cm^3 of **B** containing 'n' moles of I_2 is mixed with 20.00 cm^3 of **A** and allowed to reach equilibrium at room temperature.

The concentration of I_2 in phase **A** is determined by titrating a 5.00 cm^3 sample drawn from phase **A** with a 0.005 mol dm^{-3} solution of $Na_2S_2O_3$. The volume of $Na_2S_2O_3$ required to reach the end point was 22.00 cm^3. The concentration of I_2 in phase **B** was determined to be 0.040 mol dm^{-3}.

(i) Write the balanced chemical equation for the reaction between $Na_2S_2O_3$ and I_2.

(ii) Calculate the concentration of I_2 in phase **A**.

(iii) Calculate the value of the partition coefficient, K_D where $K_D = \frac{[I_2]_B}{[I_2]_A}$.

(iv) Calculate the total number of moles of I_2 in the two phases **A** and **B**.

(4.5 *marks*)

(*b*) The above experiment was repeated under the same conditions, that is, at the same temperature, using the same amount of I_2 and the same volumes, but with the addition of I^- ions to phase **A**. The system was then thoroughly shaken and allowed to reach equilibrium. The volume of 0.005 mol dm^{-3} $Na_2S_2O_3$ solution required to titrate the I_2 in a 5.00 cm^3 sample of phase **A** was 41.00 cm^3. The concentration of I_2 in phase **B** was then determined to be 0.030 mol dm^{-3}.

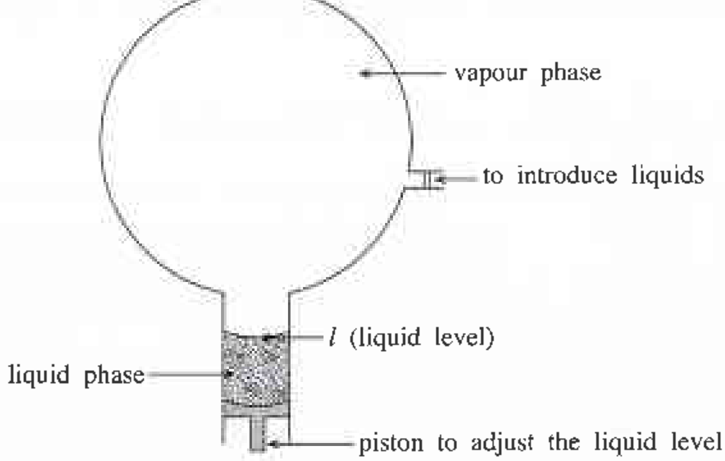
(i) Calculate the amount of I_2 (moles) expected in 5.00 cm^3 of phase **A**, based on the partition coefficient for the distribution of I_2 between the phases **A** and **B**.

(ii) Calculate the amount (moles) of I_2 reacted with $Na_2S_2O_3$ in the above titration.

(iii) Considering the different iodine species present in phase **A**, explain why the answers obtained in parts (*b*)(i) and (*b*)(ii) above are different.

(3.5 *marks*)

(*c*) Liquids **X** and **Y** form an ideal solution obeying Raoult's law.



Initially only liquid **X** was introduced in to an evacuated rigid container as shown in the figure.

[*see page eleven*

Maintaining the liquid level at l, the system was allowed to reach equilibrium at 400 K. The pressure of the container was measured to be 3.00×10^4 Pa. The volume of the vapour phase when the liquid level is at l was 4.157 dm^3. Then liquid **Y** was introduced in to the container, mixed with liquid **X** and the system was allowed to reach equilibrium at 400 K. The liquid level was maintained at l. The molar ratio of **X**:**Y** in the liquid phase was found to be 1:3. The pressure of the container was measured to be 5.00×10^4 Pa.

(i) What is the saturated vapour pressure of **X** at 400 K?

(ii) Calculate the mole fractions of **X** and **Y** in the liquid phase at equilibrium.

(iii) Calculate the partial pressure of **X** at equilibrium after the addition of **Y**.

(iv) Calculate the partial pressure of **Y** at equilibrium.

(v) Calculate the saturated vapour pressure of **Y**.

(vi) Calculate the amounts (in moles) of **X** and **Y** in the vapour phase.

(vii) When a mixture of the liquids **X** and **Y** is subjected to fractional distillation, state which compound would distill out first from the fractional distillation column. Give reason/s for your answer.

(7.0 *marks*)

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

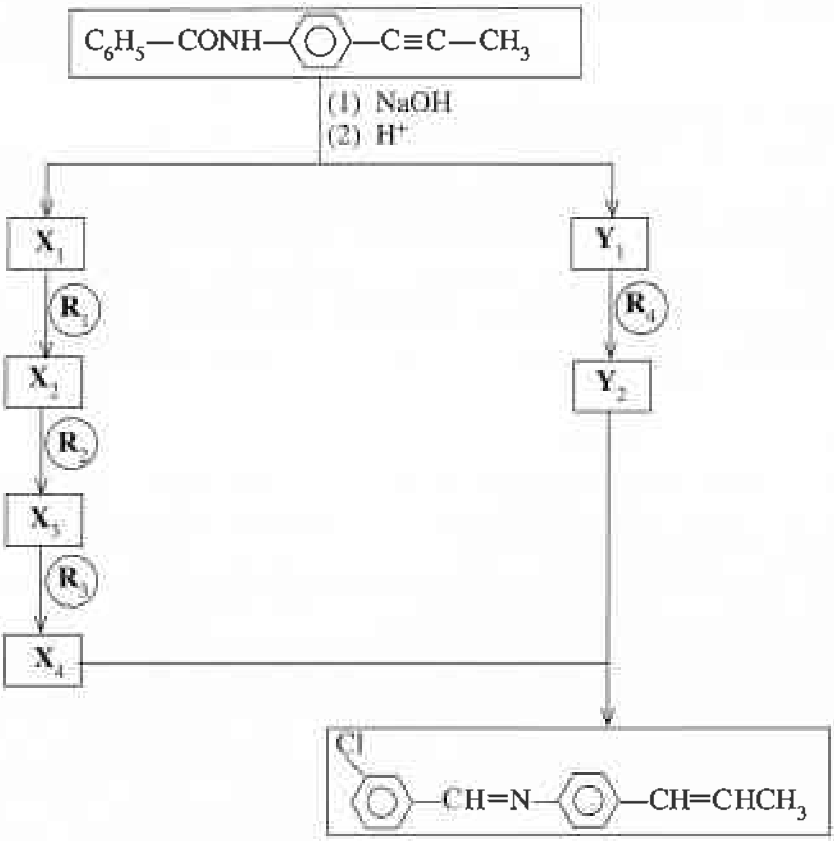
$$C_2H_5CH_2CHO \longrightarrow C_2H_5COCH_3$$

List of chemicals
aqueous NaOH, HBr, alcoholic KOH, $NaBH_4$, $H^+/KMnO_4$

Your conversion should not exceed 7 steps.

(6.0 *marks*)

(*b*) Identify $\mathbf{R_1}$—$\mathbf{R_4}$ and $\mathbf{X_1}$—$\mathbf{X_4}$ and $\mathbf{Y_1}$, $\mathbf{Y_2}$ in order to complete the following reaction scheme.



(6.0 *marks*)

[*see page twelve*

(*c*) (i) Give the mechanism of the following reaction.

$$C_2H_5OH \ + \ HBr \longrightarrow C_2H_5Br \ + \ H_2O$$

(ii) State whether the above reaction is a nucleophilic substitution reaction or an electrophilic substitution reaction. Identify the nucleophile or electrophile as appropriate.

(iii) State giving reasons which of the two compounds, phenol (C_6H_5OH) or ethanol (C_2H_5OH) is more acidic.

(3.0 *marks*)

PART C — ESSAY

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

8. (*a*) An aqueous solution **P** contains **two** cations and **two** anions. The following experiments were carried out to identify these cations and anions.

Cations

	Experiment	Observation
①	**P** was acidified with dilute HCl and H_2S was bubbled through the solution.	A clear solution was obtained.
②	The above solution was boiled till all the H_2S was removed. A few drops of conc. HNO_3 were added and the solution was heated further. The resulting solution was cooled and NH_4Cl/NH_4OH was added.	A brown precipitate (**Q**) was formed.
③	**Q** was removed by filtration and H_2S was bubbled through the filtrate.	A pale pink precipitate (**R**) was formed.
④	**R** was removed by filtration and the filtrate was boiled till all the H_2S was removed. $(NH_4)_2CO_3$ was added to the solution.	A clear solution was obtained.
⑤	Dilute NaOH was added to a **fresh portion** of **P**.	A dirty-green precipitate and a while precipitate were formed.

Experiments for precipitates **Q** and **R**:

	Experiment	Observation
⑥	**Q** was dissolved in dil. HNO_3 and a salicylic acid solution was added.	A light purple solution was obtained.
⑦	**R** was dissolved in dilute acid and dil. NaOH was added to the solution.	A white precipitate was formed. It turned brown on standing.

Anions

		Test	Observation
⑧	I.	$BaCl_2$ solution was added to **P**.	A white precipitate was formed.
	II.	The white precipitate was separated by filtration and dil. HCl was added to the precipitate.	The white precipitate was not dissolved.
⑨		Cl_2 water and chloroform were added to a portion of the filtrate from ⑧ II, and the mixture was throughly shaken.	Chloroform layer turned yellowish-brown.

[see page thirteen

(i) Identify the **two** cations and the **two** anions in solution **P**. (Reasons are **not** required.)

(ii) Write the chemical formulae of the precipitates **Q** and **R**.

(iii) Give reasons for the following:

I. Removal of H_2S in experiment ② for cations.

II. Heating with conc. HNO_3 in experiment ② for cations.

(7.5 *marks*)

(*b*) The sample **X** contains lead, copper and an inert material. The following procedure was carried out to analyse lead and copper in **X**.

Procedure:

A mass of 0.285 g of **X** was dissolved in a slight excess of dil. HNO_3. A clear solution was obtained. A NaCl solution was added to the resulting clear solution. A white precipitate (**Y**) was formed. The precipitate was separated by filtration and the precipitate (**Y**) and filtrate (**Z**) were analysed separately.

Precipitate (Y)

The precipitate was dissolved in hot water. A solution of K_2CrO_4 was added in excess. A yellow precipitate was formed. The precipitate was separated by filtration and dissolved in dil. HNO_3. An orange coloured solution was obtained. Excess KI was added to this solution and the liberated I_2 was titrated with 0.100 mol dm^{-3} $Na_2S_2O_3$, with starch as the indicator. The volume of $Na_2S_2O_3$ required to reach the end point was 27.00 cm^3.

(Assume that the NO_3^- ions do **not** interfere with the titration.)

Filtrate (Z)

The filtrate was neutralized and excess KI was added to it. The liberated I_2 was titrated with 0.100 mol dm^{-3} $Na_2S_2O_3$, with starch as the indicator. The volume of $Na_2S_2O_3$ required to reach the end point was 15.00 cm^3.

(**Note**: Assume that the inert material was soluble in dil. HNO_3 and did **not** interfere with the experiment.)

(i) Calculate the mass percentages of lead and copper in **X**. Write balanced chemical equations where relevant.

(ii) What is the colour change at the end point in the titration carried out in the analysis of precipitate **Y**?

(Cu = 63.5, Pb = 207)

(7.5 *marks*)

9. (*a*) The following questions are based on the environment and related issues.

(i) Identify **three** greenhouse gases that contribute to global warming. State **two** consequences of global warming.

(ii) Global environmental issues caused by coal power plants are well known. Identify **one** such issue that contributes **significantly** to change in certain water quality parameters in rivers and lakes.

(iii) Name the chemical species responsible for the environmental issue identified in (ii) above and state **three** water quality parameters that are likely to be affected by this issue.

(iv) Identify **two** environmental issues that change (increase or decrease) the ozone level in the atmosphere and explain briefly how these changes take place with the aid of balanced chemical equations.

(v) I. "Most of the harmful gases in vehicle exhausts are converted to relatively harmless gases by catalytic converters." Briefly explain this statement.

II. Name the harmful gas (except CO_2) that is not converted to a less harmful gas by the catalytic converter. State briefly how this harmful gas is formed in the vehicle engine.

(7.5 *marks*)

[see page fourteen

(*b*) The flow chart given below shows the production of two important compounds $\mathbf{P_1}$ and $\mathbf{P_2}$ and three other important compounds $\mathbf{P_3}$, $\mathbf{P_4}$ and $\mathbf{P_5}$ derived from them. $\mathbf{P_1}$ is used as a raw material in the manufacture of Na_2CO_3. $\mathbf{P_3}$ can be manufactured by the reaction between $\mathbf{P_1}$ and $\mathbf{P_2}$. $\mathbf{P_3}$ is used as a fertilizer and as an explosive. $\mathbf{P_1}$ is also used in the manufacture of $\mathbf{P_4}$ which is a widely used fertilizer. $\mathbf{P_4}$ is used to synthesize an important thermosetting polymer $\mathbf{P_5}$.

M Manufacturing process

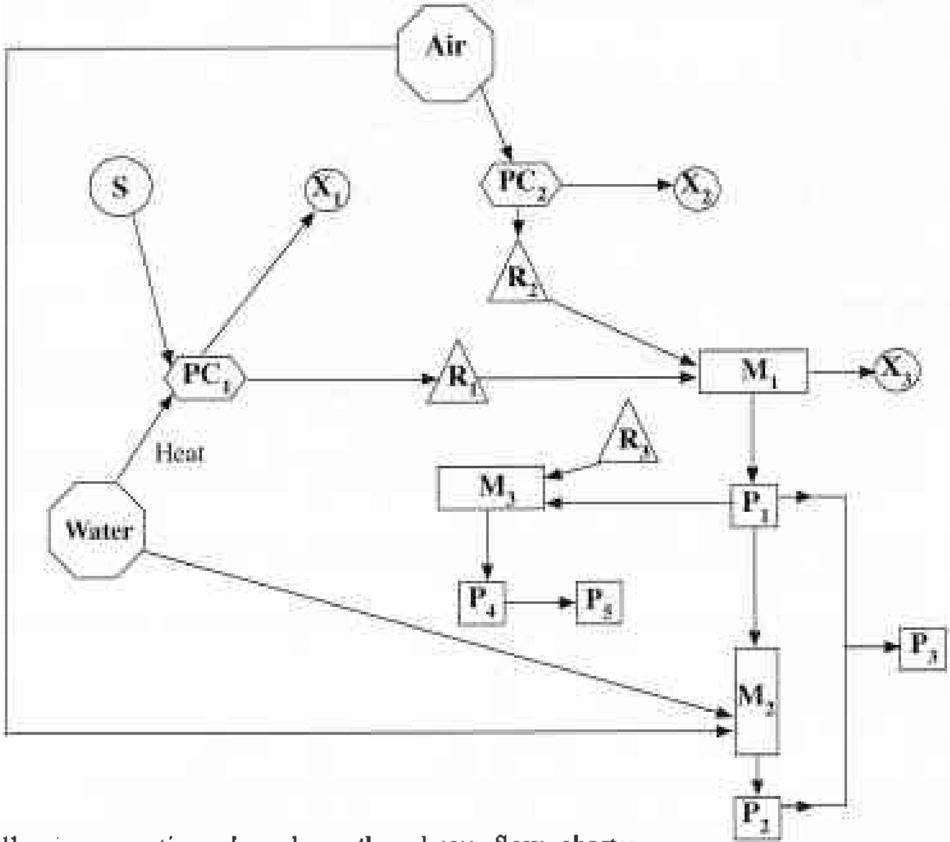
PC Physical/chemical process to obtain raw material

R Raw material

P Product

S Source of raw material

X Unreacted raw material(s) / substance discharged to the atmosphere during physical and/or chemical process



Answer the following questions based on the above flow chart.

(i) Identify $\mathbf{P_1}$, $\mathbf{P_2}$, $\mathbf{P_3}$, $\mathbf{P_4}$ and $\mathbf{P_5}$

(ii) Identify $\mathbf{R_1}$, $\mathbf{R_2}$ and $\mathbf{R_3}$

(iii) Identify $\mathbf{X_1}$, $\mathbf{X_2}$ and $\mathbf{X_3}$

(iv) Identify **S**.

(v) Briefly state the processes taking place in $\mathbf{PC_1}$ and $\mathbf{PC_2}$ giving balanced chemical equations where applicable.

(vi) Identify manufacturing processes $\mathbf{M_1}$, $\mathbf{M_2}$ and $\mathbf{M_3}$. (e.g. contact process or manufacture of H_2SO_4.)

(vii) Give balanced chemical equations with appropriate conditions, for reactions taking place in $\mathbf{M_1}$, $\mathbf{M_2}$ and $\mathbf{M_3}$.

(viii) I. Give one use of each compound $\mathbf{P_1}$ and $\mathbf{P_2}$ other than those mentioned above.

II. Give one use of $\mathbf{R_1}$ in the manufacturing process $\mathbf{P_1}$ other than being used as a raw material.

(7.5 marks)

[see page fifteen

10. (*a*) **A** and **B** are **complex ions**, (i.e. metal ion and ligands coordinated to it) with an octahedral geometry. They have the same atomic composition of $MnC_5H_3N_6$. In each complex ion, **two** types of ligands are coordinated to the metal ion. When an aqueous solution containing **A** is treated with a potassium salt, the **coordination compound C** is formed. **C** gives four ions in aqueous solution. When an aqueous solution containing **B** is treated with a potassium salt the **coordination compound D** is formed. **D** gives three ions in aqueous solution. Both **C** and **D** have an octahedral geometry.

(**Note**: The oxidation states of manganese **in A** and **B** do not change on treatment with the potassium salt).

(i) Identify the ligands coordinated to manganese in **A** and **B**.

(ii) Give the structures of **A**, **B**, **C** and **D**.

(iii) Write the electronic configurations of the manganese ions in **A** and **B**.

(iv) Write the IUPAC names of **C** and **D**.

(7.5 marks)

(*b*) (i) I. Write the reduction half reaction corresponding to the electrode, $Ag(s)\,|\,AgCl(s)\,|\,Cl^-(aq)$.

II. State whether the electrode potential of $Ag(s)\,|\,AgCl(s)\,|\,Cl^-(aq)$ depends on the Ag^+ concentration in the solution. Explain your answer.

(ii) Consider the following reaction.

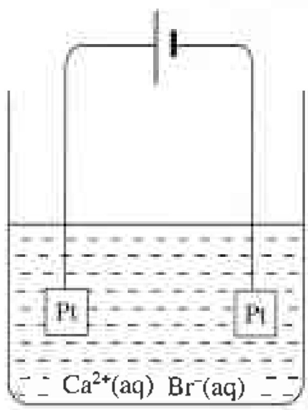
$$Fe(s) \;+\; 2H^+(aq) \;+\; \frac{1}{2}O_2(g) \longrightarrow Fe^{2+}(aq) \;+\; H_2O(l)$$

I. Write the oxidation and reduction half reactions relevant to the above reaction.

II. Given that the above reaction is the cell reaction of an electrochemical cell, determine the standard electromotive force of the cell.

$$E^o_{Fe^{2+}(aq)/Fe(s)} = -0.44\ V \qquad E^o_{H^+(aq)/O_2(g)/H_2O(l)} = 1.23\ V$$

(iii) A constant current of 100 mA was passed through 100.00 cm^3 of a 0.10 $mol\,dm^{-3}$ aqueous $CaBr_2$ solution as shown in the diagram. The temperature of the system was maintained at 25 °C.



I. Write the oxidation and reduction reactions that take place at the electrodes.

II. Calculate the time taken for the commencement of precipitation of $Ca(OH)_2(s)$. Solubility product of $Ca(OH)_2$ at 25 °C is $1.0 \times 10^{-5}\ mol^3\,dm^{-9}$. Neglect the ionization of water. Assume that the volume of the aqueous phase remains constant.

(7.5 marks)

* * *

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					
7	**Fr**	**Ra**	**Lr**	**Rf**	**Db**	**Sg**	**Bh**	**Hs**	**Mt**	**Uun**	**Uuu**	**Uub**	**Uut**	...				

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**