AL/2025/02/E-I

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இலங்கைப் பரீட்சைத் திணைக்களம்
Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2025
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2025
General Certificate of Education (Adv. Level) Examination, 2025

රසායන විද්‍යාව I
இரசாயனவியல் I
Chemistry I

02 E I

පැය දෙකයි
இரண்டு மணித்தியாலம்
Two hours

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යෝජනා සඳහා පමණි

Instructions:

- ⁕ *This paper consists of* **09** *pages.*
- ⁕ *Periodic Table printed on page* **10** *can be detached if necessary.*
- ⁕ *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 $R = 8.314\ \text{J K}^{-1}\ \text{mol}^{-1}$ Planck's constant $h = 6.626 \times 10^{-34}\ \text{J s}$
Avogadro constant $N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$ Velocity of light $c = 3 \times 10^{8}\ \text{m s}^{-1}$

1. Which of the discoveries given below is Henry Becqueral best known for?
(1) wave-particle dual nature of matter (2) radioactivity (3) X-rays
(4) structure of the nucleus (5) neutrons

2. The maximum number of electrons that can exist in an atom with quantum numbers $n = 4$ and $l = 2$ in the ground state is
(1) 3 (2) 4 (3) 6 (4) 10 (5) 18

3. The examples to best denote H-bonds, ion-induced dipole interactions, dipole-induced dipole interactions and dipole-dipole interactions are respectively given by
(1) ortho-nitrophenol, I_2 in KI(aq), HCl/Ar, ClF
(2) ortho-nitrophenol, HCl/Ar, I_2 in KI(aq), ClF
(3) para-nitrophenol, ortho-nitrophenol, ClF, I_2 in KI(aq)
(4) para-nitrophenol, I_2 in KI(aq), ClF, HCl/Ar
(5) ortho-nitrophenol, ClF, I_2 in KI(aq), HCl/Ar

4. The correct order of increasing electronegativities of C in the chemical species, CH_2Cl_2, CH_4, COF_2 and CH_2F_2 is
(1) $CH_4 < CH_2Cl_2 < CH_2F_2 < COF_2$
(2) $CH_2Cl_2 < CH_4 < CH_2F_2 < COF_2$
(3) $CH_2Cl_2 < CH_4 < COF_2 < CH_2F_2$
(4) $COF_2 < CH_2F_2 < CH_2Cl_2 < CH_4$
(5) $CH_4 < CH_2Cl_2 < COF_2 < CH_2F_2$

5. At a given temperature, $A_2(g)$ and $B_2(g)$ in a molar ratio of 1:3 were introduced into a closed-rigid container. Then the following reaction takes place.

$$A_2(g) + 3B_2(g) \rightleftharpoons 2AB_3(g)$$

At equilibrium, total pressure of the system, partial pressure of $AB_3(g)$ and the equilibrium constant are P_T, P_{AB_3} and K_P respectively. At this temperature, if $P_{AB_3} <<< P_T$, the value of P_{AB_3} is

(1) $\dfrac{3^{3/2}K_P^{1/2}P_T^2}{4}$ (2) $\dfrac{3^{3/2}K_P^{1/2}P_T^2}{16}$ (3) $\dfrac{K_P^{1/2}P_T^2}{16}$ (4) $\dfrac{K_P^{1/2}P_T^2}{4}$ (5) $\dfrac{3^3K_P^{1/2}P_T^2}{16}$

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6. A description of the atoms **X** and **Y** is given below. **Y** is heavier than **X**.

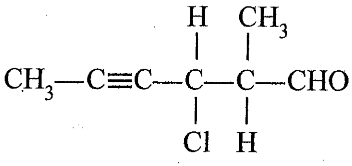
Atom	**X**	**Y**
Number of protons	a	6
Number of neutrons	7	b
Number of electrons	6	c
Mass Number	d	e

Which of the following could be correct regarding **X** and **Y**?

(1) a = 7 b = 6 c = 6 d = 13 e = 14
(2) a = 6 b = 7 c = 6 d = 13 e = 14
(3) a = 6 b = 8 c = 6 d = 13 e = 14
(4) a = 7 b = 7 c = 6 d = 14 e = 13
(5) a = 6 b = 8 c = 7 d = 13 e = 14

7. What is the IUPAC name of the given compound?

(1) 4-chloro-5-methyl-2-hexynal
(2) 3-chloro-2-formyl-4-hexyne
(3) 4-chloro-5-formyl-2-hexyne
(4) 2-methyl-3-chloro-4-hexynal
(5) 3-chloro-2-methyl-4-hexynal



$$CH_3-C\equiv C-\overset{H}{\underset{Cl}{C}}-\overset{CH_3}{\underset{H}{C}}-CHO$$

8. $CaCO_3$ and $Al_2(CO_3)_3$ undergo thermal decomposition as given below.

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$
$$Al_2(CO_3)_3(s) \longrightarrow Al_2O_3(s) + 3CO_2(g)$$

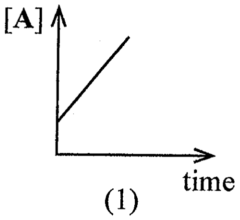
How much CO_2 is formed from $Al_2(CO_3)_3$ when 3.34 g of an equimolar mixture of $CaCO_3$ and $Al_2(CO_3)_3$ is thermally decomposed?
Relative molecular mass: $CO_2 = 44$, $CaCO_3 = 100$, $Al_2(CO_3)_3 = 234$

(1) 0.44 g (2) 1.32 g (3) 1.48 g (4) 1.76 g (5) 1.88 g

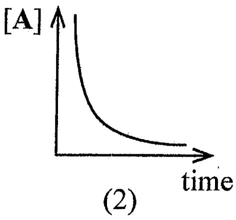
9. Which of the following species is **not** formed during the chlorination of methane in the presence of light?

(1) $\dot{C}H_3$ (2) $\dot{C}HCl_2$ (3) CH_3CH_3 (4) CH_2Cl_2 (5) $H^{\bullet}$

10. Consider the unimolecular zero order reaction **A** → **P** at temperature *T*.
Which of the following graphs represents the variation of concentration of **A** with time at temperature *T*?



(1)



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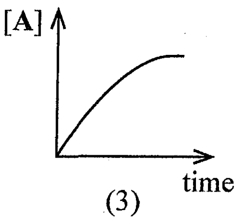

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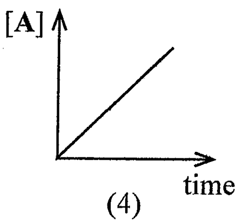

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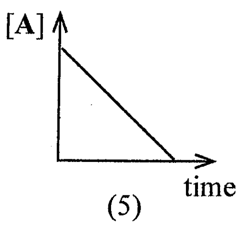

(5)

11. Identify the species which has a different shape from that of NCO^- ion.

(1) NO_2^+ (2) N_3^- (3) XeF_2 (4) CNO^- (5) SF_2

12. A volume of 25.00 cm^3 of 0.02 mol dm^{-3} KIO_3 solution was added to a titration flask. The solution was acidified with dil. H_2SO_4 and 15 cm^3 of 0.5 mol dm^{-3} KI solution was added. The liberated I_2 was titrated with a $Na_2S_2O_3$ solution using starch as the indicator. The volume of $Na_2S_2O_3$ solution required for the titration was 20.00 cm^3. The concentration of the $Na_2S_2O_3$ solution in mol dm^{-3} is

(1) 0.05 (2) 0.075 (3) 0.10 (4) 0.125 (5) 0.15

[*See page three*

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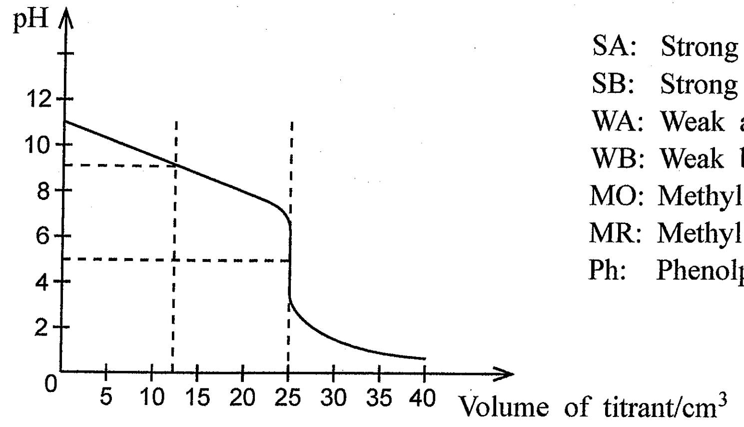
13. Enthalpy change, ΔH for the dissolution of NaOH(s) in water at temperature 23 °C is -42 kJ mol^{-1}. An amount of 20 g of NaOH(s) was dissolved in 230 g of water at 23 °C in an insulated container. The specific heat capacity of the resulting solution is 4.2 J g^{-1} K^{-1}. What is the final temperature of the solution? (Neglect the heat exchange taking place with the container). H = 1, O = 16, Na = 23

(1) 20 °C (2) 21.7 °C (3) 42 °C (4) 43 °C (5) 44.7 °C

14. The titration curve for a titration of 25.00 cm^3 mono-protic base with mono-basic acid obtained at a given temperature is shown below.

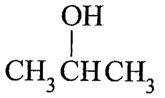


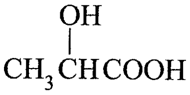
SA: Strong acid
SB: Strong base
WA: Weak acid
WB: Weak base
MO: Methyl orange
MR: Methyl red
Ph: Phenolphthalein

Which of the following descriptions is correct for the above titration curve?

	Titration	Volume of the titrant at the end point (cm^3)	pH at the end point	Suitable indicator
(1)	WA + SB	12.50	5	MR
(2)	SA + WB	25.00	5	Ph
(3)	WA + WB	12.50	9	Ph
(4)	SA + SB	25.00	7	MO
(5)	SA + WB	25.00	5	MR

15. Which of the following reaction schemes is **not** suitable to prepare 1,2-dibromopropane?

(1) 
$CH_3\overset{OH}{\overset{|}{C}}HCH_3 \xrightarrow[\Delta]{\text{conc. } H_2SO_4} \xrightarrow{Br_2}$

(2) 
$CH_3\overset{OH}{\overset{|}{C}}HCOOH \xrightarrow[\text{(2) } H^+/H_2O]{\text{(1) } LiAlH_4\text{/dry ether}} \xrightarrow{\text{excess } PBr_3}$

(3) $CH_3C\equiv CH \xrightarrow[\text{quinoline}]{H_2/Pd\text{-}BaSO_4} \xrightarrow{Br_2}$

(4) $CH_3C\equiv CH \xrightarrow{\text{excess } Br_2} \xrightarrow{H_2/Pt}$

(5) $CH_3CH_2CH_2Br \xrightarrow{\text{alcoholic KOH}} \xrightarrow{Br_2}$

16. The reaction $H_2(g) + I_2(g) \longrightarrow 2HI(g)$ proceeds through a fast equilibrium step followed by a slow elementary step. The rate law for the slow elementary step is, rate = $k'[H_2(g)]\,[I(g)]^2$. The rate constant is k'. Which of the following gives the rate law of the overall reaction in terms of $[H_2(g)]$ and $[I_2(g)]$? k is the rate constant of the overall reaction.

(1) $k[H_2(g)]\,[I_2(g)]$ (2) $k[H_2(g)]\,[I_2(g)]^2$ (3) $k[H_2(g)]^2\,[I_2(g)]$
(4) $k[H_2(g)]\,[I_2(g)]^3$ (5) $k[H_2(g)]^3\,[I_2(g)]$

17. The colours of AgBr(s) and AgI(s) are pale yellow and yellow, respectively. A solution of NaI(aq) was added to a test tube containing AgBr(s). When the contents in the test tube were stirred, its colour turned yellow. The following ideas were proposed to explain this observation.

I. The reaction, $AgBr(s) + I^-(aq) \longrightarrow AgI(s) + Br^-(aq)$ occurs.
II. K_{sp} of AgBr(s) > K_{sp} of AgI(s)
III. K_{sp} of AgBr(s) < K_{sp} of AgI(s)
IV. Concentration of $I^-(aq)$ is decreased.
V. Concentration of $Br^-(aq)$ is decreased.

Which of the above are correct with regard to this observation?

(1) I, III and V
(2) I, IV and V
(3) I, II and IV
(4) I, II and V
(5) I, III and IV

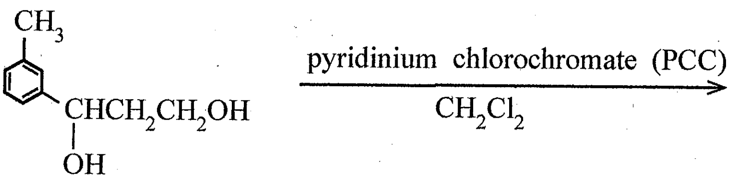
18. A small sample of water placed in a beaker at room temperature was found to have evaporated completely after 6 hours. Which of the following descriptions of this process is correct with respect to the water sample?

	ΔH	ΔS	ΔG
(1)	>0	>0	>0
(2)	>0	<0	>0
(3)	<0	<0	<0
(4)	>0	>0	<0
(5)	>0	<0	<0

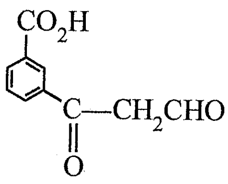
19. Which of the following statements is **incorrect** regarding *d*-block elements?

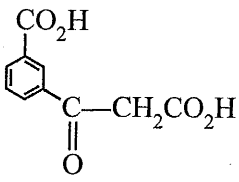
(1) VO is a basic oxide while V_2O_5 is an acidic oxide.
(2) In Mn_3O_4, manganese is present as a mixture of Mn(II) and Mn(III).
(3) When NH_4Cl/NH_4OH are added to an aqueous solution containing Fe^{3+} and Co^{2+}, only Fe^{3+} precipitates.
(4) The white precipitate formed on addition of dil. NaOH to $ZnCl_2(aq)$ is insoluble in dil. HCl.
(5) The first five elements of the 3*d* transition series achieve their maximum oxidation states by losing all 4*s* and 3*d* electrons.

20. Consider the following reaction.



Which is the major product of this reaction?

(1)


(2)


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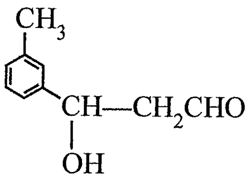

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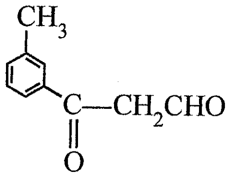

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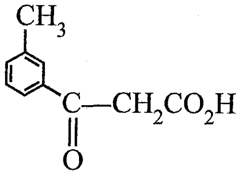


21. Given that Hg(s) $\longrightarrow$ Hg(l), $\Delta H = 2.4$ kJ mol^{-1} and normal freezing point of Hg(l) = –38 °C, what is the entropy change (J K^{-1}) when 47 g of Hg(l) freezes at the normal freezing point? (Hg = 200)

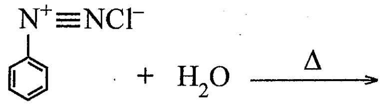
(1) 14.84 (2) 2.40 (3) –0.49 (4) –2.40 (5) –14.84

22. Which of the following statements regarding E°_{cell} and the flow of electrons is correct for the galvanic cell of Ni(s) | Ni^{2+}(aq, 1.0 mol dm^{-3}) || Cu^{2+}(aq, 1.0 mol dm^{-3}) | Cu(s), at 25 °C immediately after the electrodes are connected?

At 25 °C, $E^{\circ}_{Cu^{2+}/Cu} = 0.34$ V and $E^{\circ}_{Ni^{2+}/Ni} = -0.24$ V

(1) Electrons flow from Ni-electrode to Cu-electrode and $E^{\circ}_{\text{cell}} = 0.58$ V
(2) Electrons flow from Ni-electrode to Cu-electrode and $E^{\circ}_{\text{cell}} = -0.58$ V
(3) Electrons flow from Ni-electrode to Cu-electrode and $E^{\circ}_{\text{cell}} = 0.10$ V
(4) Electrons flow from Cu-electrode to Ni-electrode and $E^{\circ}_{\text{cell}} = 0.58$ V
(5) Electrons flow from Cu-electrode to Ni-electrode and $E^{\circ}_{\text{cell}} = 0.10$ V

23. Identify the reaction in which the diazonium ion acts as an electrophile.

(1)


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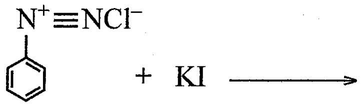

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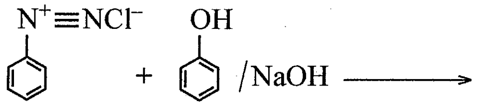
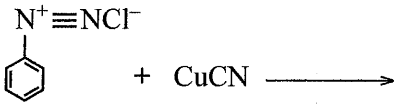
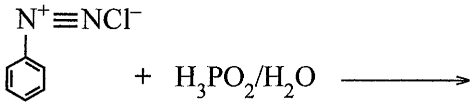


(4)


(5)


24. At the temperature at which a pure liquid will boil when it is heated in an open container, the
(1) average kinetic energy of the liquid is equal to the average kinetic energy of its vapour.
(2) average kinetic energy of the liquid is equal to the molar-entropy of its vapour.
(3) entropy of the liquid is equal to the entropy of its vapour.
(4) entropy of the vapour above the liquid is equal to the entropy of the atmosphere.
(5) vapour pressure of the liquid is equal to the atmospheric pressure above the liquid surface.

25. Consider the following information for an electrochemical cell at 25 °C.

Half-reaction	**E°/V**
$Br_2(l) + 2e \rightleftharpoons 2Br^-(aq)$	1.065
$BrO_3^-(aq) + 6H^+(aq) + 5e \rightleftharpoons \frac{1}{2}Br_2(l) + 3H_2O(l)$	1.520

Which of the following correctly shows the overall cell reaction, the corresponding E°_{cell} and the number of electrons transferred?

	Overall cell reaction	**E°/V**	**Number of electrons transferred in the overall reaction**
(1)	$3Br_2(l) + 3H_2O(l) \rightleftharpoons 5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq)$	–0.460	5
(2)	$6Br_2(l) + 6H_2O(l) \rightleftharpoons 10Br^-(aq) + 2BrO_3^-(aq) + 12H^+(aq)$	0.920	10
(3)	$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \rightleftharpoons 3Br_2(l) + 3H_2O(l)$	0.460	10
(4)	$3Br_2(l) + 3H_2O(l) \rightleftharpoons 5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq)$	–0.920	10
(5)	$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \rightleftharpoons 3Br_2(l) + 3H_2O(l)$	0.460	5

26. The following redox couples are given in the decreasing order of their reduction potentials.

$O_2(g)/H_2O(l)$, $Br_2(l)/Br^-(aq)$, $I_2(s)/I^-(aq)$, $H^+(aq)/H_2(g)$, $Cd^{2+}(aq)/Cd(s)$, $Fe^{2+}(aq)/Fe(s)$, $Zn^{2+}(aq)/Zn(s)$, $Al^{3+}(aq)/Al(s)$

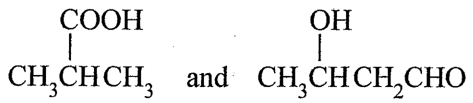
Which of the following reactions will **not** take place spontaneously in an electrochemical cell?

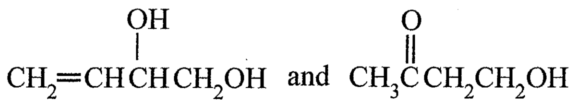
(1) $Zn(s) + Cd^{2+}(aq) \longrightarrow Cd(s) + Zn^{2+}(aq)$
(2) $2Al(s) + 3Br_2(l) \longrightarrow 2Al^{3+}(aq) + 6Br^-(aq)$
(3) $2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$
(4) $H_2(g) + I_2(g) \longrightarrow 2H^+(aq) + 2I^-(aq)$
(5) $2Al^{3+}(aq) + 3Fe(s) \longrightarrow 2Al(s) + 3Fe^{2+}(aq)$

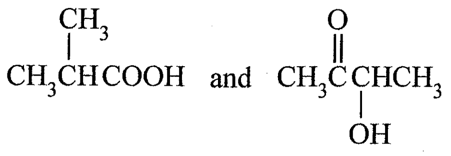
27. **X** and **Y** are two compounds having the molecular formula $C_4H_8O_2$. The observations, when **X** and **Y** are reacted with three reagents are given in the following table.

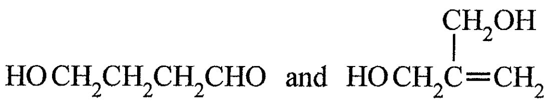
Reagent	Observation	
	X	**Y**
Na metal	a gas evolved	a gas evolved
2, 4-dinitrophenylhydrazine	no precipitate	coloured precipitate
Br_2/H_2O	decolourised	no reaction

Which of the following pairs of structures could be **X** and **Y** respectively?

(1)

$CH_3\overset{\overset{COOH}{|}}{C}HCH_3$ and $CH_3\overset{\overset{OH}{|}}{C}HCH_2CHO$

(2)

$CH_2{=}CH\overset{\overset{OH}{|}}{C}HCH_2OH$ and $CH_3\overset{\overset{O}{||}}{C}CH_2CH_2OH$

(3)

$CH_3\overset{\overset{CH_3}{|}}{C}HCOOH$ and $CH_3\overset{\overset{O}{||}}{C}\underset{\underset{OH}{|}}{C}HCH_3$

(4)

$HOCH_2CH_2CH_2CHO$ and $HOCH_2\overset{\overset{CH_2OH}{|}}{C}{=}CH_2$

(5) $HOCH_2CH{=}CHCH_2OH$ and $CH_3CH_2CH_2COOH$

28. Manganese(III) fluoride can be prepared according to the following reaction.

$$2MnI_2(s) + 13F_2(g) \longrightarrow 2MnF_3(s) + 4IF_5(l)$$

If the percentage yield is 80%, what is the mass of MnF_3 obtained when 0.10 moles of MnI_2 are reacted with excess F_2?
(F = 19, Mn = 55, I = 127)

$$\%\ \text{yield} = \frac{\text{obtained mass}}{\text{theoretical mass}} \times 100\%$$

(1) 4.48 g (2) 7.44 g (3) 8.96 g (4) 9.20 g (5) 11.20 g

29. Consider the equilibrium reaction below taking place in a closed-rigid container at 300 K.

$$\mathbf{AB}(g) + \mathbf{CD}_2(s) \rightleftharpoons \mathbf{AD}(g) + \mathbf{BD}(g) + \mathbf{C}(s)$$

In an experiment carried out at 300 K it was found that 5% of **AB**(g) converted to **AD**(g) and the total pressure of the system at equilibrium was 10 atm. The equilibrium constant K_p of the system at 300 K is

(1) $\frac{(19\times10)}{21}$ (2) $\frac{10}{(19\times21)}$ (3) $\frac{0.10}{(19\times21)}$ (4) $\frac{19\times19\times10}{39}$ (5) $\frac{19\times19\times0.10}{39}$

30. The diagram-I below depicts the variation of rates with time of forward and backward reactions of an equilibrium reaction $P \rightleftharpoons Q$ at a given temperature. At time *t*, when an additional amount of P is added to the system the change in rate of the forward reaction is also shown in diagram-I. Which line (*A*, *B*, *C*, *D* or *E*) in diagram-II shows the change in the rate of the backward reaction?

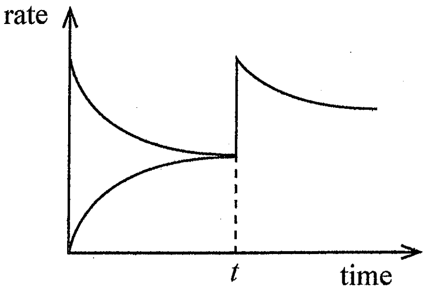


diagram-I

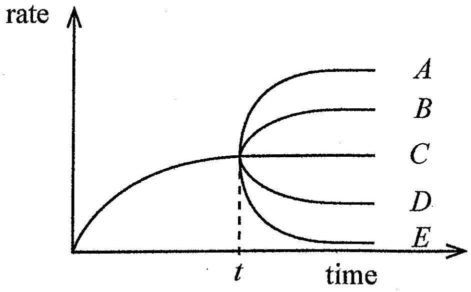


diagram-II

(1) *A* (2) *B* (3) *C* (4) *D* (5) *E*

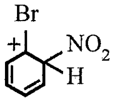
- For each of the questions **31** to **40**, one or more responses out of the four responses (*a*), (*b*), (*c*) and (*d*) given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

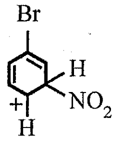
(1) if only (*a*) and (*b*) are correct.
(2) if only (*b*) and (*c*) are correct.
(3) if only (*c*) and (*d*) are correct.
(4) if only (*d*) and (*a*) are correct.
(5) if **any other** number or combination of responses is correct.

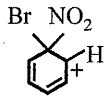
Summary of above Instructions

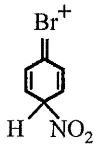
(1)	(2)	(3)	(4)	(5)
Only (*a*) and (*b*) are correct	Only (*b*) and (*c*) are correct	Only (*c*) and (*d*) are correct	Only (*d*) and (*a*) are correct	**Any other** number or combination of responses is correct

31. Consider the mechanism of the nitration of bromobenzene with conc. HNO_3/conc. H_2SO_4. Which of the following structure/structures represent/s the ion/ions formed during this reaction?

(*a*)


(*b*)


(*c*)


(*d*)


32. At a given temperature the following equilibrium exists in a closed-rigid container.

$$CO(g) + 2O_2(g) \rightleftharpoons 2CO_2(g) : \Delta H < 0$$

Which of the following statements is/are correct for this system?

(*a*) Adding more $CO_2(g)$ at the same temperature increases the amount of CO(g) with a change in the value of the equilibrium constant.
(*b*) Increasing the temperature of the system increases the amount of CO(g) with a decrease in the value of the equilibrium constant.
(*c*) Adding more CO(g) at the same temperature increases the amount of $CO_2(g)$ without a change in the value of the equilibrium constant.
(*d*) Adding more $CO_2(g)$ at the same temperature increases the amount of $O_2(g)$ with an increase in the value of the equilibrium constant.

33. The following statements refer to industrial processes. Which of them is/are correct?

(*a*) A catalyst is not required in the manufacture of NH_3 by the Haber-Bosch process.
(*b*) Citric acid is used in the purification of soap.
(*c*) In the extraction of Mg by the Dow process, CO_2 is added to the atmosphere only by the thermal decomposition of limestone or dolamite.
(*d*) HCl is the main by-product in the manufacture of NaOH using the membrane cell method.

34. Which of the following statements is/are correct regarding *s*-block elements?

(*a*) The metallic radii of Group II elements are less than the metallic radii of the corresponding Group I elements.

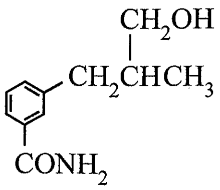
(*b*) The first ionization energies of Group II elements are greater than the first ionization energies of the corresponding Group I elements.

(*c*) The densities of Group II elements are lower than the densities of Group I elements.

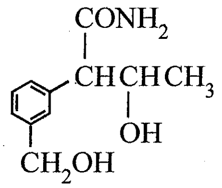
(*d*) Group II elements have weaker metallic bonds than Group I elements.

35. An organic compound **A** when heated with aqueous NaOH, liberates ammonia. The compound formed when **A** is heated with acidified $K_2Cr_2O_7$, gives a coloured precipitate with 2, 4-dinitrophenylhydrazine. Which of the following could be **A**?

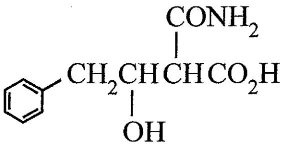
(*a*)



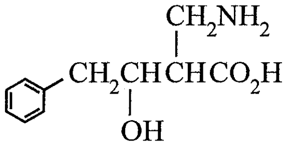
(*b*)



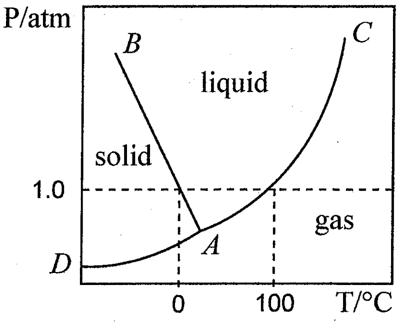
(*c*)



(*d*)



36. The phase-diagram of a pure substance **X** is shown below.



Which of the following statements is/are correct?

(*a*) The temperature needed to solidify the liquid decreases as the pressure increases.

(*b*) The freezing point of the liquid is higher than its normal freezing point at pressures above 1.0 atm.

(*c*) *A* is the triple point of **X**.

(*d*) At a temperature greater than 100 °C, a pressure above 1.0 atm is needed to liquefy the gas.

37. Which of the following statements is/are true about atmospheric ozone?

(*a*) The highest ozone concentration is at the ground level.

(*b*) Stratospheric ozone protects human life.

(*c*) Motor vehicle emissions contribute to the formation of ground level ozone.

(*d*) In the ozone layer, ozone is formed and destroyed in the presence of UV radiation.

38. The enthalpy change, ΔH, for the reaction given below at 25 °C is –126 kJ.

$$2Na_2O_2(g) + 2H_2O(l) \longrightarrow 2NaOH(aq) + O_2(g)$$

Which of the following statements about the enthalpy change is/are correct when a given amount of $Na_2O_2(s)$ is added to an excess of water at 25 °C?
(H = 1, O = 16, Na = 23)

(*a*) 63.0 kJ of energy is released when one mole of $Na_2O_2(s)$ is added.

(*b*) 31.5 kJ of energy is absorbed when 39 g of $Na_2O_2(s)$ is added.

(*c*) 63.0 kJ of energy is absorbed when one mole of $Na_2O_2(s)$ is added.

(*d*) 31.5 kJ of energy is released when 39 g of $Na_2O_2(s)$ is added.

39. Which of the following statements is/are correct regarding hydrogen halides?
(*a*) Hydrogen halides are acidic in water.
(*b*) The bond dissociation energies of hydrogen halides decrease when going down the group.
(*c*) The acidic strength of hydrogen halides decreases when going down the group.
(*d*) The bond length of hydrogen halides decreases when going down the group.

40. Which of the following statements is/are true regarding the production of H_2SO_4 by the contact process?
(*a*) The reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ is endothermic.
(*b*) Fe is the commonly used catalyst for this process.
(*c*) SO_2 is converted to SO_3 in four catalytic chambers.
(*d*) In this process pressures greater than 1 atm are not utilized.

- 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.	Among the elements of the second period of the Periodic Table, the electron gain energy of N and Be have a positive value.	Half filled shells and completely filled shells have a higher stability than other electron configurations.
42.	Ketones cannot be prepared from the reaction between esters and Grignard reagents.	Ketones react much faster than esters with Grignard reagents.
43.	In an evacuated closed-rigid container water boils at a temperature below 100 °C.	When the external pressure is low it is easy for water molecules to be released from the liquid phase to the vapour phase.
44.	The bond angles of H_2O, H_2S and H_2Se decrease in the order $H_2O > H_2S > H_2Se$.	The electronegativity of the central atom of H_2O, H_2S and H_2Se decreases in the order O > S > Se.
45.	Atmospheric water vapour contributes to global warming.	Water vapour is a greenhouse gas.
46.	For water, enthalpy of fusion ΔH_{fus} is less than the enthalpy of vaporization ΔH_{vap}.	Water molecules move further apart during fusion compared to vaporization.
47.	CH_3COCl reacts with excess aqueous NaOH to form $CH_3COO^-Na^+$.	During the reaction of an acid chloride with aqueous NaOH a tetrahedral intermediate is formed.
48.	Solubility of $Cu(OH)_2(s)$ at pH = 5 is higher than that at pH = 10.	In acidic solutions OH^- gets neutralized.
49.	In the production of Na_2CO_3 industrially, ammonification precedes carbonation.	When CO_2 is passed into an ammoniated (ammonified) brine solution, $(NH_4)_2CO_3$ is produced in high concentration.
50.	In acidic media, H_2O_2 can act as an oxidizing agent or a reducing agent, depending on the species it reacts with.	Out of the oxidation states oxygen exhibits, 0 is the most stable and abundant.

* * *

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**

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AL/2025/02/E-II(A)

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

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2025
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2025
General Certificate of Education (Adv. Level) Examination, 2025

රසායන විද්‍යාව II
இரசாயனவியல் II
Chemistry II

02 E II

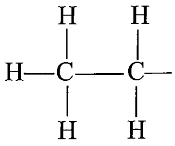
පැය තුනයි
மூன்று மணித்தியாலம்
Three hours

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. : .... උත්තර පත්‍ර පරීක්ෂකවරුන්ගේ ප්‍රයෝජනය සඳහා පමණි

- ✻ *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: 
$\mathrm{H{-}CH_2{-}CH_2{-}}$ 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		

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 **not** required.

(i) The pairing of electrons in a particular subshell **does not** take place until all the orbitals of the subshell are singly occupied by electrons with parallel spins. ....

(ii) The atomic orbitals identified by quantum numbers n and l, (I) $n = 4$ $l = 1$ (II) $n = 4$ $l = 0$ (III) $n = 3$ $l = 2$ can be placed in order of increasing energy as (III) < (II) < (I). ....

(iii) The electron pair geometry of the SOF_4 molecule is square pyramidal. ....

(iv) The second ionization energy of Li is less than that of Be. ....

(v) The electron gain energy of fluorine is a negative value. ....

(vi) Among the atoms Be, C, Si and S, the atomic radii increase in the order C < Be < S < Si. ....

(vii) The boiling point of CH_3NH_2 is higher than that of CH_3F. ....

(viii) The ionic radii of Al^{3+}, O^{2-}, F^- and S^{2-} decrease in the order $S^{2-} > F^- > O^{2-} > Al^{3+}$. ....

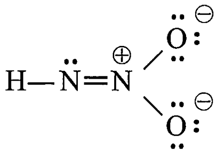
(32 *marks*)

(*b*) (i) Draw the **most** acceptable Lewis dot-dash structure for the molecule $ClSO_2F$.

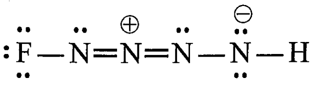
(ii) Give the oxidation state of S in the structure drawn in (i) above.

S ....

(iii) A stable Lewis dot-dash structure for the $HN_2O_2^-$ ion is given below. Draw **two** more Lewis dot-dash structures (resonance structures) for this ion. Indicate the stability of each of the structures drawn by you, relative to the structure given, by writing **stable**, **unstable** or **less stable** under the structure.



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



$:\underset{..}{\ddot{F}}-\ddot{N}=\overset{\oplus}{N}=\ddot{N}-\overset{\ominus}{\underset{..}{\ddot{N}}}-H$

$F-N^1-N^2-N^3-N^4-H$

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

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

(v) Identify 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-N^2 N^1............................ N^2............................

III. N^2-N^3 N^2............................ N^3............................

IV. N^3-N^4 N^3............................ N^4............................

V. N^4-H N^4............................ H ....

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

I. N^1-N^2 N^1............................ N^2............................

II. N^2-N^3 N^2............................ N^3............................

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

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

(viii) Arrange N^1, N^2, N^3 and N^4 atoms in **increasing** order of their electronegativities.

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

(52 *marks*)

(*c*) (i) Given below are the six successive ionization energies, IE_1–IE_6 (in kJ/mol) of an element in the third period, starting from the first ionization energy (IE_1).

IE_1	IE_2	IE_3	IE_4	IE_5	IE_6
1012	1903	2910	4956	6248	22230

Identify the element and write its electron configuration.

I. element : ....

II. electron configuration : ....

Do not write in this column.

(ii) A molecule of formula AX_5 has five A—X σ bonds. Here A and X represent symbols of elements and A is the central atom.
Complete the table below by naming the possible molecular shape and giving an example (molecular formula required) for each of the shapes.

	molecular shape	example
I. If AX_5 is polar		
II. If AX_5 is nonpolar		

(16 *marks*)

100

2. (*a*) (i) **A** is a water soluble white coloured compound. It is composed of three elements in the ratio 4:2:3 (in the increasing order of atomic mass). The atomic number of each element is less than 20. Two of these elements belong to the *p*-block of the Periodic Table. On heating **A**, a colourless, non-toxic, neutral, tri-atomic gas with a linear structure is evolved as one of the products. **A** is used as a fertilizer.

Identify **A** ....

(ii) **B** is also a water soluble white coloured compound. It is composed of the same three elements as **A**. These elements are in the ratio 4:2:2 (in the increasing order of atomic mass). On heating **B**, a colourless, odourless, homo diatomic gas having a high bond dissociation energy is evolved. This gas is obtained industrially by fractional distillation of liquified air.

Identify **B** ....

(iii) **C** is a white coloured ionic compound. It is composed of four elements in the ratio 8:2:4:1 (in the increasing order of atomic mass). The atomic number of each element is less than 20. Three of these elements are found in both **A** and **B**. On heating **C**, a colourless basic gas **X** having a strong smell, and a strong acid are formed. On addition of $BaCl_2(aq)$ to an aqueous solution of **C**, a white precipitate that is insoluble in dil. HCl is obtained.

Identify **C** ....

(iv) **D** is a white coloured ionic compound. It is composed of four elements in the ratio 8:1:2:3 (in the increasing order of atomic mass). Three of these elements are found in all three compounds **A**, **B** and **C**. Of the products formed on heating **D**, gas **X** and another gas that turns lime water milky are obtained as two of the products.

Identify **D** ....

(v) **E** is a strong acid. It is composed of the same elements as **A** and **B**. They are in the ratio 3:1:1 (**not** in the increasing order of atomic mass). **E** is a strong oxidizing agent. **E** is manufactured using **X**.

Identify **E** ....

(40 *marks*)

(*b*) Give balanced chemical equations for the reactions that take place on heating **A**, **B**, **C** and **D** identified in (*a*) above.

A ....

B ....

C ....

D .... **(32 *marks*)**

[*see page five*

(*c*) (i) Identify **X** based on the information given in part (*a*) above.

....

(ii) Name the process by which **E**, identified in part (*a*)(v) above, is manufactured using **X**.

....

(iii) State the other raw material/s used in the above process.

....

(iv) I. On reacting **X** with excess $Cl_2(g)$ a compound **Y** is formed as one of the products. Write the balanced chemical equation for this reaction.

....

II. When **Y** reacts with water, a compound that can be used to disinfect water is formed. Write the balanced chemical equation for the reaction of **Y** with water.

....

(v) Give **one** chemical test to identify **X**, along with its observation.

Test : ....

Observation : ....

(28 *marks*)

$\frac{}{100}$

3\. (*a*) HX(aq) is a weak acid with $pK_a = 4$ at 25 °C.

(i) Write the equation for the ionization of HX(aq) in an aqueous solution.

(ii) Write the expression for the equilibrium constant of (i) above.

(iii) Calculate the pH of a 0.01 mol dm^{-3} solution of HX(aq) at a temperature of 25 °C.

(iv) A volume of 10.00 cm^3 of 0.02 mol dm^{-3} NaOH(aq) solution was added to 25.00 cm^3 of 0.01 mol dm^{-3} HX(aq) solution at a temperature of 25 °C.

I. Write the chemical species present in the solution obtained.

II. What is this type of solution commonly known as?

III. Write the expression for the calculation of pH of this solution.

IV. Calculate the pH of this solution. (log values for 1–10 are given below.)

number	1	2	3	4	5	6	7	8	9	10
log value	0.00	0.30	0.48	0.60	0.70	0.78	0.85	0.90	0.95	1.00

V. Calculate the volume of 0.02 mol dm^{-3} NaOH(aq) solution required to be mixed with 100.00 cm^3 of 0.01 mol dm^{-3} HX(aq) to obtain a solution of pH 4.00.

(**70** ***marks***)

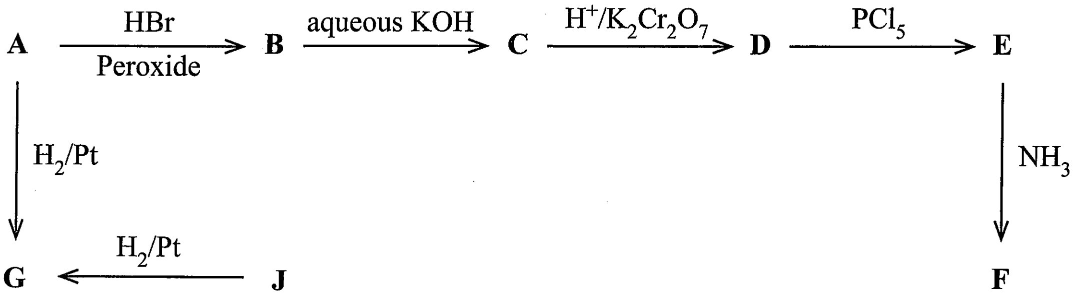
(*b*) At 25 °C, $MgF_2(s)$ is sparingly soluble in water ($K_{sp} = 6.4 \times 10^{-9}$ mol^3 dm^{-9}). Calculate the maximum mass of $MgF_2(s)$ that is completely soluble in 500.00 cm^3 of 0.20 mol dm^{-3} NaF(aq) solution. Assume that there is no change in volume of the solution upon the addition of $MgF_2(s)$. (F = 19, Mg = 24)

$\frac{}{100}$

(**30** ***marks***)

4. (*a*) Consider the reaction scheme given below, in which,

- **A** is a hydrocarbon having the molecular formula C_5H_{10}.
- **D** has the molecular formula $C_5H_{10}O_2$. It exhibits optical isomerism. When **D** is reacted with aqueous Na_2CO_3, CO_2 is liberated.
- **J** has the molecular formula C_5H_8. **J** gives a precipitate with ammonical $AgNO_3$.



(i) Draw the structures of **A, B, C, D, E, F, G** and **J** in the relevant boxes.

A **B**

C **D**

E **F**

G **J**

Do not write in this column.

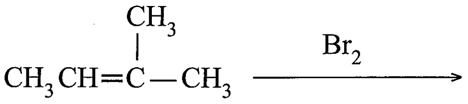
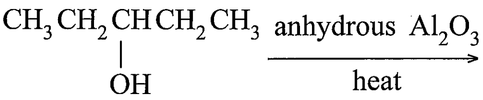
- When **J** is reacted with $HgSO_4$/dil. H_2SO_4, **K** is formed. **K** can be converted to **G** in one (01) step.

(ii) Draw the structure of **K** and give the reagent/s that can be used to convert **K** to **G** in the relevant boxes.

K	**Reagent/s**

(60 *marks*)

(*b*) For the reactions given below, write the type of reaction [nucleophilic addition (A_N), electrophilic addition (A_E), nucleophilic substitution (S_N), electrophilic substitution (S_E), elimination (E)] and the major product in the relevant cages in the table.

	Reaction	Reaction type	Major product
(i)	 $CH_3CH{=}\overset{\overset{\Large CH_3}{|}}{C}{-}CH_3 \xrightarrow{Br_2}$		
(ii)	 $CH_3CH_2\underset{\underset{\Large OH}{|}}{CH}CH_2CH_3 \xrightarrow[\text{heat}]{\text{anhydrous } Al_2O_3}$		
(iii)	$CH_3CH_2CH_2OH \xrightarrow{HBr}$		

(18 *marks*)

(*c*) Draw the structure of the major product **L** of the reaction given below. Write the mechanism of this reaction.

$+ \; (CH_3)_3CCl \xrightarrow[AlCl_3]{\text{anhydrous}}$

L

mechanism:

(22 *marks*)

100

✻ ✻

[*see page nine*

8892

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

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2025
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2025
General Certificate of Education (Adv. Level) Examination, 2025

රසායන විද්‍යාව **II**
இரசாயனவியல் **II**
Chemistry II

02 E II

උත්තර පත්‍ර පරීක්ෂකවරුන්ගේ
යෝජනය සඳහා පමණි

✻ Universal gas constant $R = 8.314\ \text{J K}^{-1}\ \text{mol}^{-1}$
✻ Avogadro constant $N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

PART B — ESSAY

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

5. (*a*) At 450 °C, 1.0 mol of $N_2(g)$ and 2.0 mol of $H_2(g)$ were mixed in a 1.0 dm^3 previously evacuated closed-rigid container and allowed to reach the equilibrium given below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

It was found that 1.0 mol of $NH_3(g)$ was present at the equilibrium.

(i) Calculate the total pressure of the equilibrium system at 450 °C ($RT = 6 \times 10^3\ \text{J mol}^{-1}$ at 450 °C).

(ii) Calculate the partial pressures of $N_2(g)$, $H_2(g)$ and $NH_3(g)$ at 450 °C in the equilibrium system.

(iii) Calculate the equilibrium constant K_P of the system at 450 °C.

(iv) Using the value obtained for K_P in (iii) above, calculate the equilibrium constant K_C of the system at 450 °C.

(v) State what changes, if any, take place in the values of partial pressures of $N_2(g)$, $H_2(g)$ and $NH_3(g)$ and the value of K_P, when 1.0 mol of Ar(g) is added to the above system at 450 °C (calculations are **not** required).

(60 *marks*)

(*b*) Assume that ΔH° and ΔS° of the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ do not change with the temperature.

(i) Predict the effect on the equilibrium concentration of $NH_3(g)$ when the temperature of the system is increased.

(ii) For the above reaction, $\Delta H^\circ = -90\ \text{kJ mol}^{-1}$ and $\Delta S^\circ = -200\ \text{J K}^{-1}\ \text{mol}^{-1}$.
Show that the prediction you made in (i) above is correct by calculating the ΔG° values of the reaction at 27 °C and 527 °C.

(iii) Consider the reaction $2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$ occurring in a closed-rigid container at 450 °C.

I. Predict the effect of increasing the temperature on the value of $\left(\dfrac{[NH_3(g)]^2}{[N_2(g)][H_2(g)]^3}\right)$.

II. Comment on the time taken for the reaction above to reach the equilibrium in the presence and absence of a catalyst at 450 °C.

III. Explain your answer in II above.

(60 *marks*)

(*c*) (i) Define the 'normal boiling point' of a pure liquid.

(ii) Write the equilibrium present at the boiling point of pure $CCl_4(l)$.

(iii) Given that, $\Delta H^\circ_{CCl_4(g)} = -95\ \text{kJ mol}^{-1}$, $\Delta H^\circ_{CCl_4(l)} = -128\ \text{kJ mol}^{-1}$
$\Delta S^\circ_{CCl_4(g)} = 309\ \text{J K}^{-1}\ \text{mol}^{-1}$, $\Delta S^\circ_{CCl_4(l)} = 214\ \text{J K}^{-1}\ \text{mol}^{-1}$

Calculate the normal boiling point of $CCl_4(l)$.

(30 *marks*)

[*see page ten*

6. (*a*) Consider the reaction $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$ at 25 °C.
The results of an initial-rate experiment carried out at 25 °C for the reaction above are shown below. $[NO(g)]_0$ and $[Cl_2(g)]_0$ are the initial concentrations of NO(g) and $Cl_2(g)$, respectively.

Experiment	$[NO(g)]_0$/mol dm^{-3}	$[Cl_2(g)]_0$/mol dm^{-3}	$\frac{-\Delta[Cl_2(g)]}{\Delta t}$/mol dm^{-3} s^{-1}
1	0.25	0.50	0.75
2	0.25	1.00	3.00
3	0.50	2.00	24.00

(i) Write the expressions for the rate of the reaction with respect to each species appearing in the equation of the reaction.

(ii) Write the rate expression/law for the reaction if the order of the reaction with respect to NO(g) and $Cl_2(g)$ are **a** and **b** respectively, and the rate constant is *k*.

(iii) Calculate the values of **a** and **b** and overall order of the reaction.

(iv) Calculate the rate constant *k* of the reaction at 25 °C.

(v) Calculate the rate of disappearance of $Cl_2(g)$ at 25 °C when the initial concentrations of NO(g) and $Cl_2(g)$ are 0.50 and 0.10 mol dm^{-3}, respectively.

(vi) Calculate the rate of formation of NOCl(g) at 25 °C when the rate of disappearance of $Cl_2(g)$ is 4.5 mol dm^{-3} s^{-1} at 25 °C.

(vii) Calculate the rate of formation of NOCl(g) at 25 °C when the initial concentrations of NO(g) and $Cl_2(g)$ are 0.20 and 0.30 mol dm^{-3}, respectively.

(75 *marks*)

(*b*) The reaction of Cu powder with nitric acid results in the formation of a red-brown gas containing N and O. In an experiment carried out at 33 °C, the produced gas was collected to a 150 cm^3 vessel. The pressure and mass of the gas were 831.4 mm Hg and 0.300 g, respectively. Calculate the molar mass of the produced gas and give its chemical formula. State the assumption/s made. (1 mm Hg = 133.3 Pa, N = 14, O = 16)

(35 *marks*)

(*c*) Two identical containers A and B, contain equal volumes of pure water and 3.0 mol dm^{-3} glycerol aqueous solution, respectively, at a given temperature. Giving reasons, compare,

(i) the vapour pressures of the contents in A and B.

(ii) the boiling points of the contents in A and B.

(15 *marks*)

(*d*) At a given temperature, an ideal binary liquid mixture was prepared by mixing liquids C and D in a closed container. At this temperature, vapour pressures of C and D are P_C and P_D respectively, and saturated vapour pressures of C and D are P_C° and P_D° respectively. The mole fractions of C and D in the liquid phase are X_C and X_D respectively.

(i) Derive the expression for the relative lowering of the vapour pressure of C at this temperature.

(ii) A solution was prepared by dissolving 1.0 mol of glycerol in 900 g of water at 25 °C. Calculate

I. the relative lowering of the vapour pressure (mm Hg)

II. the vapour pressure (mm Hg) of the solution.

At 25 °C, saturated vapour pressure of water is 24 mm Hg. (H = 1, O = 16)
At 25 °C, saturated vapour pressure of glycerol is negligible.

(25 *marks*)

[*see page eleven*

7. (*a*) The following electrochemical cell was constructed to study the electrochemical behaviour of the reaction, $3Cu^+(aq) + Au^{3+}(aq) \rightarrow 3Cu^{2+}(aq) + Au(s)$ at 25 °C. The cell consists of an Au(s) electrode in a beaker with 1.0 mol dm^{-3} $Au(NO_3)_3(aq)$ solution and a Pt(s) electrode in another beaker filled with a solution containing 1.0 mol dm^{-3} each of $CuNO_3(aq)$ and $Cu(NO_3)_2(aq)$. The two half-cells were connected *via* a salt-bridge filled with saturated $KNO_3(aq)$ solution and a voltmeter.

$$E^\circ_{Au^{3+}(aq)/Au(s)} = 1.50 \text{ V and } E^\circ_{Cu^{2+}(aq)/Cu^+(aq)} = 0.16 \text{ V at } 25\ ^\circ\text{C}.$$

(i) Draw a sketch of the electrochemical cell.

(ii) Identify the anode and the cathode of the cell and write the respective half reactions.

(iii) Identify the positive and negative terminals of this electrochemical cell.

(iv) Calculate E°_{cell} at 25 °C.

(v) Does the mass of the Pt(s) electrode increase, decrease or remain the same as the cell operates? Explain your answer.

(vi) State the ionic species present in the Au(s)-half cell before and after the cell operates.

(vii) After the cell has operated for 30 minutes at 25 °C, 0.197 g of Au(s) was deposited on the Au(s) electrode.

I. Calculate the number of Au moles deposited. (Au = 197 g mol^{-1})

II. Calculate the current (mA) which passed through the cell during the 30 minute period, assuming the current remained constant.

(75 *marks*)

(*b*) (i) **A**, **B**, **C**, **D** and **E** are coordination compounds. They have an octahedral geometry.

I. Give the structural formulae or draw the structures of these coordination compounds, selecting the appropriate species from the list given below.

Na^+, Cu^+, Cu^{2+}, Br^-, NH_3

A : An equal number of two types of ligands are coordinated to the metal ion. Its complex ion has a charge of –1.

B : Two types of ligands are coordinated to the metal ion. On addition of $AgNO_3(aq)$ to an aqueous solution of **B**, a pale yellow precipitate soluble in conc. NH_4OH is formed.

C and **D** : **C** and **D** contain the same elements. However, the complex ion of **C** has a charge of –2, while that of **D** has a charge of –3.

E : Only one type of ligand is coordinated to the metal ion. **E** gives two ions in aqueous solution.

Note : ● A complex ion has one metal ion with multiple ligands coordinated to it.

II. Give the IUPAC name of **E**.

(ii) **X** and **Y** are complex ions of a *d*-block metal ion M(II).

They have a square planar geometry.

X : Only ethylenediamine is coordinated to M(II).

Y : Ethylenediamine and H_2O are coordinated to M(II).

Write the structural formulae of **X** and **Y** and draw their structures.

Note :
- ● A complex ion has one metal ion with multiple ligands coordinated to it.
- ● Structure of ethylenediamine $NH_2—CH_2—CH_2—NH_2$.
- ● Ethylenediamine coordinates to M(II) through both N atoms.
- ● Use 'en' to denote ethylenediamine in the structural formula.

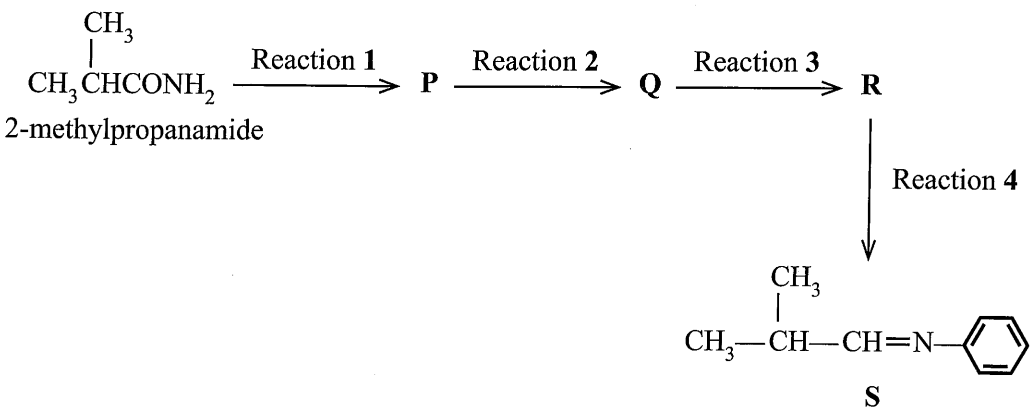
(75 *marks*)

[*see page twelve*

PART C — ESSAY

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

8. (*a*) Given below is a reaction scheme for the preparation of compound **S** using 2-methylpropanamide as the starting compound.



Complete the above reaction scheme by drawing the structures of compounds **P**, **Q** and **R**, and writing the appropriate reagents for reactions **1** – **4**, selecting **only** from the list given below.

List of reagents:
LiAlH$_4$/dry ether, NaNO$_2$, dil. HCl, Pyridinium chlorochromate (PCC), $C_6H_5NH_2$

(**35** ***marks***)

(*b*) Consider the reaction of 2-methyl-2-butene with HBr.

(i) Give the structures of the two products that could possibly be formed in this reaction.

(ii) Stating the type of the reaction and considering the mechanism of the reaction, explain which of these two products is the major product.

(**30** ***marks***)

(*c*) Consider the two compounds, phenol and acetic acid.

(i) State which of these two compounds is more acidic.

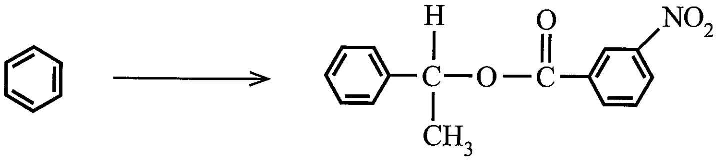
(ii) Write the chemical equations for the equilibria existing in aqueous medium for each of the compounds.

(iii) Draw the resonance structures of the organic chemical species written in the answer to (ii) above.

(iv) Considering the resonance structures, explain your answer to (i) above.

(**50** ***marks***)

(*d*) Show how you would carry out the following conversion in not more than **five (05)** steps.



(**35** ***marks***)

[*see page thirteen*

9. (*a*) An aqueous solution **Y** contains four cations **P**, **Q**, **R** and **S**. The following experiments were carried out in sequence to identify these cations.

	Experiment	**Observation**
1	**Y** was acidified with dil. HCl.	a white precipitate ($\mathbf{P_1}$)
2	$\mathbf{P_1}$ was separated by filtration and H_2S was bubbled through the resulting filtrate.	no precipitate
3	The above filtrate was boiled to completely remove the H_2S. A few drops of conc. HNO_3 were added, the solution was boiled, cooled and NH_4Cl/NH_4OH were added.	a brown precipitate ($\mathbf{Q_1}$)
4	$\mathbf{Q_1}$ was separated by filtration and H_2S was bubbled through the resulting filtrate.	a black precipitate ($\mathbf{R_1}$)
5	$\mathbf{R_1}$ was separated by filtration, the resulting filtrate was boiled to completely remove the H_2S, cooled and NH_4Cl/NH_4OH were added. This solution was warmed and $(NH_4)_2CO_3$(aq) was added in excess.	a white precipitate ($\mathbf{S_1}$)

The following tests were carried out for the precipitates.

Precipitate	**Test**	**Observation**
$\mathbf{P_1}$	dil. NH_4OH was added to $\mathbf{P_1}$.	a colourless solution ($\mathbf{P_2}$)
	The following solutions were added separately to aliquots of $\mathbf{P_2}$.	
	I. KI(aq)	a dark yellow precipitate ($\mathbf{P_3}$)
	II. $Na_2S_2O_3$(aq) / Δ	a black precipitate ($\mathbf{P_4}$)
$\mathbf{Q_1}$	$\mathbf{Q_1}$ was dissolved in dil. HNO_3. The following solutions were added separately to aliquots of the resulting solution.	
	I. NH_4SCN(aq)	a deep red solution ($\mathbf{Q_2}$)
	II. $K_4[Fe(CN)_6]$(aq)	a dark blue precipitate ($\mathbf{Q_3}$)
$\mathbf{R_1}$	$\mathbf{R_1}$ was dissolved in warm dil. HCl, the solution was cooled and the following solutions were added separately to aliquots of the resulting solution.	
	I. a few drops of dil. NH_4OH	a green precipitate ($\mathbf{R_2}$)
	II. excess dil. NH_4OH	a deep blue solution ($\mathbf{R_3}$)
	III. a few drops of dil. NH_4OH/ dimethylglyoxime (DMG)	a deep red precipitate ($\mathbf{R_4}$)
$\mathbf{S_1}$	$\mathbf{S_1}$ was dissolved in dil. HCl. The following solutions were added separately to aliquots of the resulting solution.	
	I. dil. H_2SO_4	a white precipitate that was insoluble in dil. HNO_3 ($\mathbf{S_2}$)
	II. K_2CrO_4(aq)	a yellow precipitate ($\mathbf{S_3}$)
	$\mathbf{S_1}$ was subject to the flame test.	a pale green flame

Identify the four cations **P**, **Q**, **R** and **S**. Write chemical formulae of the compounds/species $\mathbf{P_1}$–$\mathbf{P_4}$, $\mathbf{Q_1}$–$\mathbf{Q_3}$, $\mathbf{R_1}$–$\mathbf{R_4}$, and $\mathbf{S_1}$–$\mathbf{S_3}$ associated with each cation.

Note : Chemical equations and reasons are **not** required.

(75 *marks*)

[*see page fourteen*

(*b*) The mineral named siderite, contains mainly $FeCO_3$. Siderite is formed when calcium ions (Ca^{2+}) of $CaCO_3$ in limestone are replaced by ferrous ions (Fe^{2+}) over a long period of time. Therefore, $FeCO_3$ in siderite is mixed with $CaCO_3$. In addition, siderite also contains impurities such as silica in small quantities.

8.5 g of such a siderite sample was thermally decomposed at 900 °C under oxygen free conditions until a constant mass was obtained. The mass of the remaining sample was 5.2 g. During thermal decomposition, $CaCO_3$ is converted to CaO and $FeCO_3$ is converted to FeO.

Another 1.7 g of the above siderite sample was dissolved in excess dilute H_2SO_4 acid, filtered, and the resulting solution was diluted to 100.00 cm^3 with distilled water. When 25.00 cm^3 of the resulting solution was titrated with 0.04 mol dm^{-3} $KMnO_4$, the end-point reading of $KMnO_4$ was 12.50 cm^3.

Assume that the quantities of metals other than Fe and Ca in the siderite sample are negligible. (C = 12, O = 16, Ca = 40, Fe = 56)

(i) Calculate the mass percentage of $CaCO_3$ in the siderite sample.

(ii) Calculate the percentage of impurities, other than $CaCO_3$, in the siderite sample.

(iii) When 8.5 g of the siderite sample was thermally decomposed in the presence of oxygen, $FeCO_3$ decomposes giving Fe_2O_3 and Fe_3O_4 in 1:1 molar ratio whereas $CaCO_3$ decomposes to CaO.

Calculate the mass of the remaining residue after this thermal decomposition.

(75 *marks*)

10. (*a*) Consider the industrial manufacture of TiO_2.

(i) Name the process by which TiO_2 is produced from rutile.

(ii) Name the required raw materials (other than rutile) for the above process.

(iii) Name the **two** main steps associated with the above process.

(iv) Give balanced chemical equations for the reactions which take place under each of the above mentioned steps.

(v) Explain how the above process contributes to Global Warming.

(50 *marks*)

(*b*) NO, NO_2, SO_2, CH_4, CF_2Cl_2 and CF_2HCl are among the pollutants that contribute to various environmental problems. Except for the two halogenated compounds, the others are released into the environment through both natural processes and human activities.

(i) State **two** natural processes and **two** human activities that release NO to the environment.

(ii) Acid rain, global warming, ozone layer depletion and photochemical smog are four major atmospheric problems. Briefly describe each of these phenomena and identify **two** gases each from the above list that make a **significant contribution** to each of the phenomena.

(iii) Explain why CF_2HCl was introduced as an alternative to CF_2Cl_2 as an attempt to protect the ozone layer.

(iv) In an industrial zone where sulfur containing coal is used as a fuel, it is reported that fish are dying in nearby lakes. Giving reasons suggest a suitable method to control this environmental problem.

(50 *marks*)

[*see page fifteen*

(*c*) (i) I. Give the classification of polymers according to the type of reaction taking place during the polymerization process.

II. Draw **two** structures each, for each of the classes of polymers you stated in (I) above.

(ii) I. Draw the structure of the repeating unit of natural rubber.

II. Write the name of the process that is used to change the elastic property of natural rubber and name the substance used in the process.

(iii) I. Give a balanced chemical equation to show the synthesis of biodiesel using a triglyceride and methanol.

II. Write the name given to the type of reaction used in the production of biodiesel.

III. Calculate the mass of biodiesel produced from 7.22 g of the triglyceride of $CH_3(CH_2)_{12}COOH$. ($H = 1$, $C = 12$, $O = 16$)

(50 *marks*)

* * *

The Periodic Table

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