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නව නිර්දේශය/புதிய பாடத்திட்டம்/New Syllabus

NEW

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

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2020
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2020
General Certificate of Education (Adv. Level) Examination, 2020

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

1. Consider the following discoveries made with regard to the atomic structure.

I. Positive rays inside a cathode ray tube
II. Radioactivity by certain types of nuclei

The two scientists who discovered the above stated I and II respectively, are,

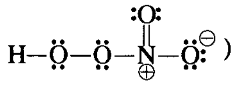
(1) J. J. Thomson and Henry Becquerel
(2) Eugen Goldstein and Robert Millikan
(3) Henry Becquerel and Eugen Goldstein
(4) J. J. Thomson and Ernest Rutherford
(5) Eugen Goldstein and Henry Becquerel

2. The number of electrons in the manganese atom (Mn, Z = 25) that have quantum numbers $l = 0$ and $m_l = -1$ respectively are,

(1) 6 and 4 (2) 8 and 12 (3) 8 and 5 (4) 8 and 6 (5) 10 and 5

3. **M** is an element that belongs to the second period in the Periodic Table. It forms a covalent molecule $\mathbf{M}Cl_3$ which has a dipole moment. The group of the Periodic Table to which **M** belongs is,

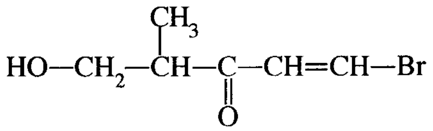
(1) 2 (2) 13 (3) 14 (4) 15 (5) 16

4. The number of **unstable** Lewis dot-dash structures that can be drawn for the peroxynitric acid molecule (formula HNO_4,  $H-\ddot{O}-\ddot{O}-\overset{:O:}{\overset{\|}{\underset{\oplus}{N}}}-\ddot{O}\!:^{\ominus}$) is,

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

5. The IUPAC name of the given compound is,

(1) 1-bromo-4-methyl-5-hydroxypent-1-en-3-one
(2) 5-bromo-1-hydroxy-2-methylpent-4-en-3-one
(3) 1-bromo-5-hydroxy-4-methylpent-1-en-3-one
(4) 5-bromo-2-methyl-3-oxopent-4-en-1-ol
(5) 1-bromo-4-methyl-3-oxopent-1-enol



$HO-CH_2-\overset{CH_3}{\overset{|}{CH}}-\underset{O}{\underset{\|}{C}}-CH=CH-Br$

6. The **decreasing** order of radii of the species O, O^{2-}, F, F^-, S^{2-}, Cl^- is,

(1) $S^{2-} > Cl^- > O^{2-} > F^- > O > F$
(2) $S^{2-} > Cl^- > O^{2-} > F^- > F > O$
(3) $Cl^- > S^{2-} > O^{2-} > F^- > O > F$
(4) $Cl^- > S^{2-} > F^- > O^{2-} > O > F$
(5) $S^{2-} > Cl^- > O^{2-} > O > F^- > F$

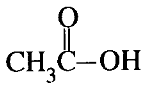
7. A rigid-closed container contains n_1 moles of an ideal gas at temperature T_1(K) and pressure P_1(Pa). When an additional amount of the gas was inserted into the container, the new temperature and pressure were T_2 and P_2, respectively. The total number of moles of the gas now in the container is,

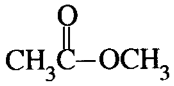
(1) $\dfrac{n_1T_1P_1}{T_2P_2}$ (2) $\dfrac{n_1T_1P_2}{T_2P_1}$ (3) $\dfrac{T_2P_2}{n_1T_1P_1}$ (4) $\dfrac{n_1T_2P_2}{T_1P_1}$ (5) $\dfrac{n_1T_2P_1}{T_1P_2}$

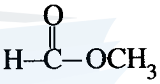
8. The total number of electrons exchanged in the reaction of the oxidation of ethanol (C_2H_5OH) to acetic acid (CH_3COOH) using acidic $K_2Cr_2O_7$ solution is,

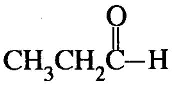
(1) 6 (2) 8 (3) 10 (4) 12 (5) 14

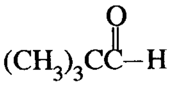
9. Which compound of the following, can undergo aldol condensation, when reacted with aqueous NaOH?

(1) 
$CH_3\overset{O}{\overset{\|}{C}}-OH$

(2) 
$CH_3\overset{O}{\overset{\|}{C}}-OCH_3$

(3) 
$H-\overset{O}{\overset{\|}{C}}-OCH_3$

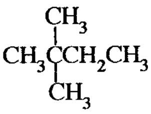
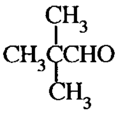
(4) 
$CH_3CH_2\overset{O}{\overset{\|}{C}}-H$

(5) 
$(CH_3)_3C\overset{O}{\overset{\|}{C}}-H$

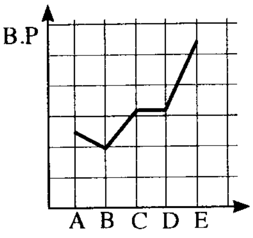
10. AX(s), A_2Y(s) and AZ(s) are sparingly soluble salts in water having K_{sp} values of 1.6×10^{-9}, 3.2×10^{-11} and 9.0×10^{-12}, respectively at 25 °C. Which of the following shows the order of the three saturated solutions of these salts in decreasing concentration of cation A^+(aq), at 25 °C ?

(1) AX(s) > A_2Y(s) > AZ(s)
(2) A_2Y(s) > AX(s) > AZ(s)
(3) AX(s) > AZ(s) > A_2Y(s)
(4) A_2Y(s) > AZ(s) > AX(s)
(5) AZ(s) > A_2Y(s) > AX(s)

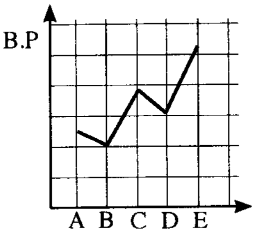
11. Consider the following compounds.

	$CH_3CH_2CH_2CH_2CH_2CH_3$	 $CH_3\overset{CH_3}{\underset{CH_3}{C}}CH_2CH_3$	$CH_3CH_2CH_2CH_2CHO$	 $CH_3\overset{CH_3}{\underset{CH_3}{C}}CHO$	$CH_3CH_2CH_2CH_2CH_2OH$
	A	**B**	**C**	**D**	**E**
Relative molecular mass	86	86	86	86	88

Variation of boiling points of these compounds is best shown by,



(1)



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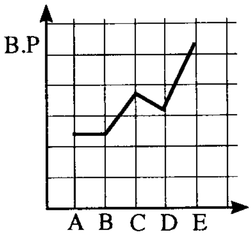
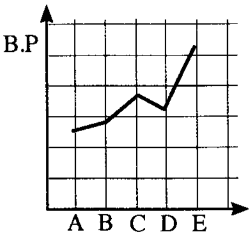


(3)



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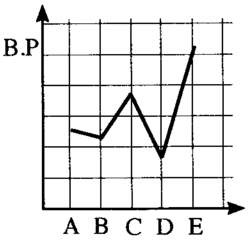


(5)

12. The **increasing** order of covalent character of the chemical species NaCl, Na_2S, KF and KCl is,

(1) KF < NaCl < KCl < Na_2S
(2) KCl < NaCl < KF < Na_2S
(3) KF < KCl < NaCl < Na_2S
(4) Na_2S < NaCl < KCl < KF
(5) KF < Na_2S < NaCl < KCl

13. Standard combustion enthalpies of $H_2(g)$, C(s) and $CH_3OH(l)$ at 298 K are $-286\ \text{kJ mol}^{-1}$, $-393\ \text{kJ mol}^{-1}$ and $-726\ \text{kJ mol}^{-1}$, respectively. Enthalpy of vaporization of $CH_3OH(l)$ is $+37\ \text{kJ mol}^{-1}$. Enthalpy of formation (kJ mol^{-1}) of one mole of **gaseous** CH_3OH at 298 K is,

(1) −276 (2) −239 (3) −202 (4) +84 (5) +202

14. Phosphorous can be prepared in an electric furnace as given by the following balanced chemical equation.

$$2\,Ca_3(PO_4)_2 + 6\,SiO_2 + 10\,C \longrightarrow 6\,CaSiO_3 + 10\,CO + P_4$$

When 620 g of $Ca_3(PO_4)_2$, 180 g of SiO_2 and 96 g of C were reacted, 50 g of P_4 were obtained. Under these conditions, the limiting reagent (reagent that is completely consumed) and percentage yield of P_4 respectively are, (C = 12, O = 16, Si = 28, P = 31, Ca = 40)

(1) $Ca_3(PO_4)_2$ and 80.7% (2) SiO_2 and 80.7% (3) C and 50.4%
(4) SiO_2 and 40.3% (5) C and 25.2%

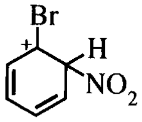
15. Consider the following two equilibria occurring in two separate rigid-closed containers under the same conditions.

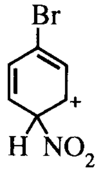
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)\ ;\ K_{P_1} = 3.0 \times 10^{-4}$$
$$NH_3(g) + H_2S(g) \rightleftharpoons NH_4HS(g);\ K_{P_2} = 8.0 \times 10^{-4}$$

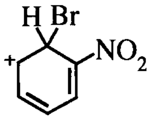
Under these conditions K_p for the equilibrium $2H_2S(g) + N_2(g) + 3H_2(g) \rightleftharpoons 2NH_4HS(g)$ is,

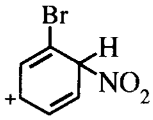
(1) 5.76×10^{-12} (2) 7.2×10^{-10} (3) 1.92×10^{-8} (4) 3.40×10^{-6} (5) 3.75×10^{-2}

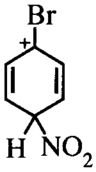
16. Consider the nitration reaction of bromobenzene. Resonance stabilized carbocation intermediates are formed during this reaction. Which of the following is **not** a resonance structure of these intermediates?

(1) 

(2) 

(3) 

(4) 

(5) 

17. A reaction which is non-spontaneous at room temperature and 1 atm pressure becomes spontaneous at high temperature at the same pressure. Which of the following is correct for this reaction at room temperature? (Assume that ΔH and ΔS do not change with temperature and pressure.)

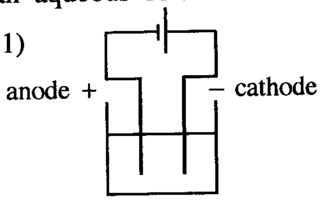
	ΔG	ΔH	ΔS
(1)	Positive	Positive	Positive
(2)	Positive	Negative	Negative
(3)	Positive	Negative	Positive
(4)	Negative	Positive	Negative
(5)	Negative	Negative	Negative

18. The de Broglie wavelength of a neutron travelling with a velocity v is λ. If the kinetic energy E ($E = \frac{1}{2}mv^2$) of this neutron is increased four times, the new de Broglie wavelength would be,

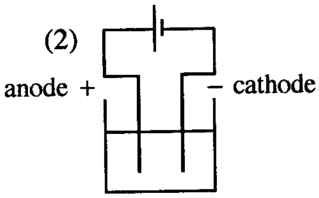
(1) $\frac{\lambda}{2}$ (2) $\frac{\lambda}{4}$ (3) 2λ (4) 4λ (5) 16λ

19. Which of the following correctly shows the electrolytic cell constructed for the electrolysis of an aqueous solution of the salt MX?

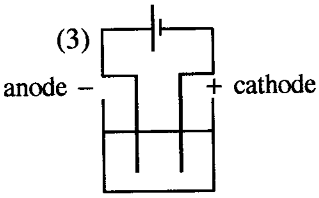
(1)



(2)



(3)



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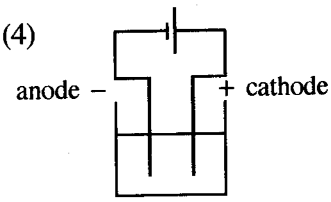
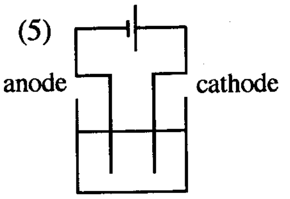


(5)



20. Which of the following statements is correct regarding the reaction between a carboxylic acid and an alcohol to give an ester?

(1) The overall reaction is a nucleophilic addition reaction of a carbonyl compound.
(2) It is a reaction in which the alcohol acts as a nucleophile.
(3) It is a reaction which occurs with the cleavage of the O–H bond of the carboxylic acid.
(4) It is a reaction which occurs with the cleavage of the C–O bond of the alcohol.
(5) It is an acid-base reaction.

21. Decomposition of 1 mol of $CH_3OH(l)$ occurs at high temperatures as follows.

$$CH_3OH(l) \rightarrow CO(g) + 2H_2(g); \; \Delta H = +128\text{ kJ}$$

Which of the following is **incorrect** for the above reaction? (H = 1, C = 12, O = 16)

(1) The heat absorbed when 1 mol of $CH_3OH(g)$ is decomposed is less than 128 kJ.
(2) Enthalpy of $CO(g) + 2H_2(g)$ is higher than the enthalpy of $CH_3OH(l)$.
(3) 128 kJ of heat is released when 1 mol of CO(g) is formed.
(4) 128 kJ of heat is absorbed during the decomposition of a mole of reactant.
(5) 128 kJ of heat is absorbed when 32 g of products are formed.

22. Identify the **incorrect** statement from the following.

(1) Electron gain energy of nitrogen [N(g)] is positive.
(2) Dilution of $BiCl_3(aq)$ solution with water gives a white precipitate.
(3) H_2S gas can act both as an oxidizing agent and a reducing agent.
(4) The effective nuclear charge (Z^*) felt by a valence electron in He is less than 2.
(5) Aluminium is inert towards N_2 gas even when heated to a high temperature.

23. The concentration of a dilute aqueous solution of a weak acid HA is C mol dm^{-3} and its acid dissociation constant is K_a at 298 K. Which of the following expressions gives the pH of the solution at 298 K?

(1) $pH = \frac{1}{2}pK_a - \frac{1}{2}\log C$

(2) $pH = -\frac{1}{2}pK_a - \frac{1}{2}\log C$

(3) $pH = -\frac{1}{2}pK_a + \frac{1}{2}\log C$

(4) $pH = -\frac{1}{2}pK_a - \frac{1}{2}\log(1/C)$

(5) $pH = \frac{1}{2}pK_a - \frac{1}{2}\log(1/C)$

[*See page five*

24. The strength of a H_2O_2 solution can be expressed as the volume of O_2 produced at standard temperature and pressure (STP). For example, a litre of 20 **volume strength** H_2O_2 solution will produce 20 litres of O_2 gas at STP ($2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$). (Assume that 1 mole of gas has 22.4 litres volume at STP.)

A bottle labelled **X** contains H_2O_2 solution. When 25.0 cm^3 of solution **X** was titrated with 1.0 mol dm^{-3} $KMnO_4$ in the presence of dilute H_2SO_4 the volume required to reach the end point was 25.0 cm^3. The volume strength of solution **X** is,

(1) 15 (2) 20 (3) 25 (4) 28 (5) 30

25. $M(OH)_2(s)$ is a sparingly water soluble salt formed by the reaction between $M^{2+}(aq)$ and $OH^-(aq)$ ions at 298 K. The solubility (mol dm^{-3}) of $M(OH)_2(s)$ in water at pH = 5 is, ($K_{sp\,M(OH)_2} = 4.0 \times 10^{-36}$ at 298 K).

(1) $\sqrt{2} \times 10^{-18}$ (2) 2×10^{-18} (3) 1×10^{-18} (4) $\sqrt[3]{2} \times 10^{-12}$ (5) 1×10^{-12}

26. Which of the following correctly denotes the standard galvanic cell constructed by using a standard hydrogen electrode, a standard Mg–electrode and a salt-bridge at 298 K?

(1) $Mg(s) \mid Mg^{2+}$ (aq, 1.00 mol dm^{-3}) $\parallel H^+$ (aq, 1.00 mol dm^{-3}) $\mid H_2(g) \mid Pt(s)$

(2) $Pt(s) \mid H_2(g) \mid H^+$(aq, 1.00 mol dm^{-3}) $\parallel Mg^{2+}$ (aq, 1.00 mol dm^{-3}) $\mid Mg(s)$

(3) $Mg(s), Mg^{2+}$ (aq, 1.00 mol dm^{-3}) $\parallel H^+$(aq, 1.00 mol dm^{-3}) $\mid H_2(g) \mid Pt(s)$

(4) $Mg(s) \mid Mg^{2+}$ (aq, 1.00 mol dm^{-3}), H^+(aq, 1.00 mol dm^{-3}), $H_2(g) \mid Pt(s)$

(5) $Pt(s), H_2(g) \mid H^+$(aq, 1.00 mol dm^{-3}) $\parallel Mg^{2+}$ (aq, 1.00 mol dm^{-3}), Mg(s)

27. The following procedure was carried out at 298 K to determine the distribution coefficient K_D of a monobasic organic acid between dichloromethane and water. 50.00 cm^3 of a 0.20 mol dm^{-3} aqueous solution of acid were mixed vigorously with 10.00 cm^3 of dichloromethane and the two layers were allowed to separate. Thereafter, the dichloromethane layer in the bottom of the flask was drained out. 10.00 cm^3 of 0.02 mol dm^{-3} NaOH(aq) solution were required to neutralize the acid remaining in the aqueous layer. (Assume that the acid does not dimerize in the organic phase.) K_D of the acid between **dichloromethane and water** at 298 K is,

(1) 0.05 (2) 0.25 (3) 4.00 (4) 20.00 (5) 245.00

28. A reaction $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(g)$ occurs in a rigid-closed container at a given temperature. After a certain time, it was found that the rate of the reaction with respect to consumption of $C_2H_4(g)$ was x mol dm^{-3} s^{-1}. Which of the following shows the rates of consumption of $O_2(g)$, formation of $CO_2(g)$ and formation of $H_2O(g)$ respectively, during that time?

	rate / mol dm^{-3} s^{-1}		
	$O_2(g)$	$CO_2(g)$	$H_2O(g)$
(1)	$\frac{3}{x}$	$\frac{2}{x}$	$\frac{2}{x}$
(2)	x	x	x
(3)	$\frac{x}{3}$	$\frac{x}{2}$	$\frac{x}{2}$
(4)	$\frac{1}{x}$	$\frac{1}{x}$	$\frac{1}{x}$
(5)	$3x$	$2x$	$2x$

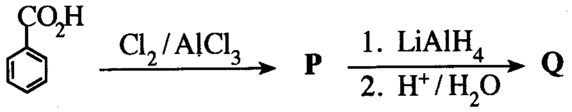
29. Consider the following reaction occurring in a rigid-closed container at temperature T.

$$\mathbf{M}(g) + \mathbf{Q}(g) \rightarrow \mathbf{R}(g) + \mathbf{Z}(g)$$

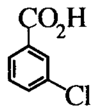
The rate of reaction doubled when the concentration of **M** was doubled. The rate of reaction is 5.00×10^{-4} mol dm^{-3} s^{-1} when the concentrations of **M** and **Q** are 1.0×10^{-5} mol dm^{-3} and 2.0 mol dm^{-3} respectively. The rate constant of the reaction under these conditions is,

(1) 2.5×10^{-4} s^{-1} (2) 12.5 s^{-1} (3) 25 s^{-1} (4) 50 s^{-1} (5) 500 s^{-1}

30. Consider the following reaction scheme.



P and **Q** respectively could be,

(1)


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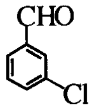
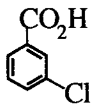


(2)


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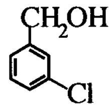

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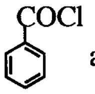

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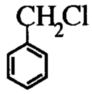

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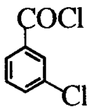

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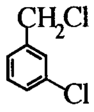
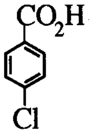
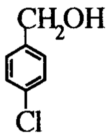


(5)


and


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

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

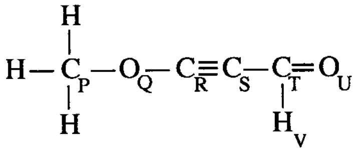
Summary of above Instructions

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

31. Which of the following statement/s is/are correct with regard to 3*d*-block elements and their compounds?

(*a*) Among the 3*d*-block elements, Sc is not considered as a transition element.
(*b*) The radii of atoms (Sc to Cu) decrease from left to right.
(*c*) $[Ni(NH_3)_6]^{2+}$ is blue in colour whereas $[Zn(NH_3)_4]^{2+}$ is colourless.
(*d*) The IUPAC name of K_2NiCl_4 is dipotassium tetrachloronickelate(II).

32. Which statement/s is/are correct regarding the following molecule?



$$H-\overset{H}{\underset{H}{C_P}}-O_Q-C_R\equiv C_S-\underset{H_V}{C_T}=O_U$$

(*a*) Atoms labelled P, Q, R and S lie on a straight line.
(*b*) Atoms labelled Q, R, S and T lie on a straight line.
(*c*) Atoms labelled R, S, T, U and V lie on the same plane.
(*d*) Atoms labelled R, S, T and U lie on a straight line.

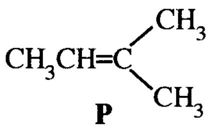
33. 0.01 moles of $N_2(g)$, 0.10 moles of $H_2(g)$ and 0.40 moles of $NH_3(g)$ were inserted into a 1.0 dm^3 rigid-closed container and allowed to reach equilibrium at 500 K as given below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad K_C = 2.0 \times 10^2\ mol^{-2}\ dm^6$$

Which of the following statement/s is/are correct for the changes in the system from the initial stage to equilibrium? Q_C is the reaction quotient.

(*a*) Initially $Q_C > K_C$; $NH_3(g)$ starts to produce $N_2(g)$ and $H_2(g)$ and the system reaches equilibrium.
(*b*) Initially $Q_C < K_C$; $NH_3(g)$ starts to produce $N_2(g)$ and $H_2(g)$ and the system reaches equilibrium.
(*c*) Initially $Q_C < K_C$; $N_2(g)$ and $H_2(g)$ react to form $NH_3(g)$ and the system reaches equilibrium.
(*d*) Initially $Q_C > K_C$; $N_2(g)$ and $H_2(g)$ react to form $NH_3(g)$ and the system reaches equilibrium.

34. Which of the following statement/s regarding the reaction between compound **P** and HCl to form an alkyl halide is/are correct?



P

(*a*) The major product is 2-chloro-2-methylbutane.
(*b*) A secondary carbocation is formed as an intermediate in this reaction.
(*c*) In one of the steps of the reaction, the HCl bond is cleaved to give a chlorine radical ($Cl^{\bullet}$).
(*d*) In one of the steps of the reaction, a nucleophile reacts with a carbocation.

35. A binary liquid mixture prepared by mixing two liquids in a closed evacuated container at a given temperature shows a negative deviation from Roult's Law. Which of the following statement/s is/are correct for this system?

(*a*) Total vapour pressure of the mixture is less than the expected total vapour pressure should it behave as an ideal mixture.
(*b*) Heat is released when the mixture is formed.
(*c*) Number of molecules in the vapour phase of the mixture is greater than the expected number of molecules should it behave as an ideal mixture.
(*d*) Heat is absorbed when the mixture is formed.

36. Which of the following statement/s is/are correct with regard to CFC, HCFC and HFC?

(*a*) Both classes of compounds CFC and HCFC have the ability to produce chlorine free radicals in the upper atmosphere (stratosphere).
(*b*) Both classes of compounds HFC and HCFC have the ability to produce chlorine free radicals in the upper atmosphere (stratosphere).
(*c*) All three classes of compounds CFC, HCFC and HFC are strong greenhouse gases.
(*d*) All three classes of compounds CFC, HCFC and HFC contribute significantly to ozone layer depletion.

37. Which of the following statement/s is/are correct with regard to halogens, noble gases and their compounds?

(*a*) Hypochlorous ion disproportionates rapidly in acidic solutions.
(*b*) Xe forms a series of compounds with F_2 gas, among which XeF_4 has a square planar geometry.
(*c*) Among the hydrogen halides, HF has the highest bond dissociation energy per mole.
(*d*) Boiling points of halogens increase down the group as a result of increasing strength of London forces.

38. Which of the following statement/s is/are correct regarding the Daniell cell when it operates at room temperature? ($E^{\circ}_{cell} = +1.10$ V)

(*a*) Net electron flow occurs from Zn to Cu.
(*b*) The equilibrium $Zn^{2+}(aq) + 2e \rightleftharpoons Zn(s)$ shifts to the right.
(*c*) A liquid-junction potential is created due to the presence of a salt-bridge.
(*d*) The equilibrium $Cu^{2+}(aq) + 2e \rightleftharpoons Cu(s)$ shifts to the right.

39. Which of the following statement/s is/are correct for ideal gases and real gases at constant temperature?

(*a*) At very high pressures, the volume of a real gas is higher than that of an ideal gas.
(*b*) At high pressures, real gases tend to behave as ideal gases.
(*c*) At very high pressures, the volume of a real gas is lower than that of an ideal gas.
(*d*) At low pressures, real gases tend to behave as ideal gases.

40. Which of the following statement/s is/are correct regarding some industrial processes?

(*a*) The first two steps involved in the manufacture of Na_2CO_3 by Solvay Process are endothermic.
(*b*) The presence of Mg^{2+}, Ca^{2+} and SO_4^{2-} ions in brine, hinders the production of NaOH using the membrane cell method.
(*c*) The first step involved in the manufacture of nitric acid by Ostwald method is the oxidation of NH_3 gas using O_2 in air in the presence of a catalyst to give NO_2 gas.
(*d*) High temperature and low pressure conditions are employed in the manufacture of NH_3 gas using Haber-Bosh process.

[*See page eight*

- 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 oxides of Cr and Mn, CrO and MnO are acidic, while CrO_3 and Mn_2O_7 are basic.	The acidic/basic nature of the oxides of Cr and Mn is dependant on the oxidation number of the metal.
42.	An acidic buffer solution can be prepared by mixing a weak acid HA(aq) with its sodium salt NaA(aq).	When $OH^-(aq)$ or $H^+(aq)$ ions are added to a buffer solution, the added amounts of $OH^-(aq)$ or $H^+(aq)$ ions are removed through the reactions; $OH^-(aq) + HA(aq) \rightarrow A^-(aq) + H_2O(l)$ and $H^+(aq) + A^-(aq) \rightarrow HA(aq)$ respectively.
43.	Essential oils can be extracted from plants by steam distillation at a temperature below 100 °C.	At the temperature at which a mixture of essential oil and water boils, the total vapour pressure of the system is less than the atmospheric pressure.
44.	At a given temperature and pressure the molar volumes of two different ideal gases are different from each other.	At 0 °C temperature and 1 atm pressure, the molar volume of an ideal gas is $22.4\ dm^3\ mol^{-1}$.
45.	All compounds having a C=C bond show diastereoisomerism.	Any two isomers which are not mirror images of each other are diastereoisomers.
46.	Hydrogenation of benzene is more difficult than hydrogenation of alkenes.	Addition of hydrogen to benzene results in the loss of aromatic stabilization.
47.	The reaction that takes place between SO_3 gas and water in the production of sulphuric acid is endothermic.	SO_3 gas reacts with concentrated H_2SO_4 to give oleum.
48.	Reaction between ammonia and an alkylhalide gives a mixture of primary, secondary and tertiary amines and a quaternary ammonium salt.	Primary, secondary and tertiary amines can react as nucleophiles.
49.	If $P + Q \rightarrow R$ is a first order reaction with respect to the reactant P, the graph of rate against concentration of P gives a straight line passing through the origin.	Initial rate of a first order reaction is independent of the concentration of reactant(s).
50.	On a sunny day, strong photochemical smog can be seen in a city with heavy traffic congestion.	Photochemical smog is caused entirely by scattering of solar radiation by small particles and water droplets that are emitted by vehicle exhaust systems.

***

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**

7048

නව නිර්දේශය/புதிய பாடத்திட்டம்/New Syllabus

NEW

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

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2020
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2020
General Certificate of Education (Adv. Level) Examination, 2020

රසායන විද්‍යාව II
இரசாயனவியல் II
Chemistry II

02 E II

පැය තුනයි
மூன்று மணித்தியாலம்
Three hours

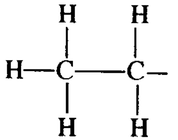
අමතර කියවීම් කාලය - මිනිත්තු 10 යි
மேலதிக வாசிப்பு நேரம் - 10 நிமிடங்கள்
Additional Reading Time - 10 minutes

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

Index No. : ....

* *A Periodic Table is provided on page 15.*
* ***Use of calculators is not allowed.***
* *Universal gas constant,* $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
* *Avogadro constant,* $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
* **In answering this paper, you may represent alkyl groups in a condensed manner.**

Example:



$$\mathrm{H{-}\overset{H}{\underset{H}{C}}{-}\overset{H}{\underset{H}{C}}{-}}$$

group may be shown as CH_3CH_2-

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

* *Answer **all** the questions on the question paper itself.*
* *Write your answer in the space provided for each question. Please note that the space provided is sufficient for the answer and that extensive answers are not expected.*

❑ PART B and PART C — Essay (pages 09 - 14)

* *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*) Write the answers to the questions given below on the dotted lines.

(i) Of the three ions Na^+, Mg^{2+} and F^-, which one has the **smallest** ionic radius? ....

(ii) Of the three elements C, N and O, which one has the **highest** second ionization energy? ....

(iii) Of the three compounds H_2O, HOCl and OF_2, which one has the **most** electronegative oxygen atom? ....

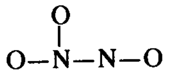
(iv) Of the three elements Be, C and N, which one will liberate energy when an electron is added to its atom [$Y(g) + e \rightarrow Y^-(g)$; Y = Be, C, N] in the gaseous state? ....

(v) Of the three ionic compounds NaF, KF and KBr, which one has the **highest** solubility in water? ....

(vi) Of the three compounds HCHO, CH_3F and H_2O_2, which one has the **strongest** intermolecular forces? ....

(24 *marks*)

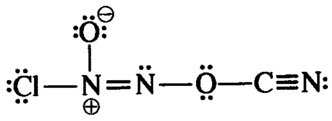
(*b*) (i) Draw the **most** acceptable Lewis dot-dash structure for the ion, $N_2O_3^{2-}$. Its skeleton is given below.

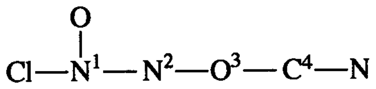


$\mathrm{O{-}\overset{\overset{\displaystyle O}{|}}{N}{-}N{-}O}$

(ii) Draw **three** more Lewis dot-dash structures (resonance structures) for this ion. Indicate the relative stabilities of the structures drawn by you, when compared with the most acceptable structure drawn in (i) above, by writing '**less stable**' or '**unstable**' under these structures.

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





$\mathrm{Cl{-}\overset{\overset{\displaystyle O}{|}}{N^1}{-}N^2{-}O^3{-}C^4{-}N}$

	N^1	N^2	O^3	C^4
VSEPR pairs around the atom				
electron pair geometry around the atom				
shape around the atom				
hybridization of the atom				

[*see page three*

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Do not write in this column.

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

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

I. $Cl—N^1$ Cl .... N^1 ....

II. $N^1—O$ N^1 .... O ....

III. $N^1—N^2$ N^1 .... N^2 ....

IV. $N^2—O^3$ N^2 .... O^3 ....

V. $O^3—C^4$ O^3 .... C^4 ....

VI. $C^4—N$ C^4 .... N ....

(v) 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. $C^4—N$ C^4 .... N ....

C^4 .... N ....

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

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

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

.... < .... < .... < .... **(56 *marks*)**

(*c*) Consider the following information.

I. The atoms **A** and **B** combine to form a heterodiatomic molecule **AB** that has a σ bond. This is represented as **A–B**.

II. The electronegativity of **A** is less than that of **B** $(X_A < X_B)$.
X = electronegativity of the atom

III. The inter-nuclear distance between **A** and **B** atoms (d_{A-B}) of the **AB** molecule is given by the following equation.

$$d_{A-B} = r_A + r_B - c(X_B - X_A)$$

r = atomic radius, c = 9 pm

Note: d and r are measured in picometres (pm). (1 pm = 10^{-12} m)

Based on the above information, answer the following questions.

(i) What is the name used to identify the type of σ bond between **A** and **B**?

....

(ii) Show how fractional charges (δ+ and δ–) are located in the molecule **AB**.

....

(iii) Write the equation to calculate the dipole moment (μ) of molecule **AB** and show its direction.

(iv) Calculate the percentage of ionic character of the H–F bond in the HF molecule using the data given below.

Inter-nuclear distance of H_2 (d_{H-H}) = 74 pm
Inter-nuclear distance of F_2 (d_{F-F}) = 144 pm
Electronegativity of H = 2.1
Electronegativity of F = 4.0
Dipole moment of HF = 6.0×10^{-30} C m
Charge of an electron = 1.6×10^{-19} C

100

(**20** ***marks***)

2. (*a*) **A, B, C** and **D** are chlorides of *p*-block elements. These elements have atomic numbers less than 20. A description of the products ($\mathbf{P_1 - P_9}$) formed when **A** is reacted with a limited amount of water and **B, C** and **D** are reacted with excess water are given below.

Compound	**Description of products**	
A	$\mathbf{P_1}$	a compound with a covalent network structure
	$\mathbf{P_2}$	a strong monobasic acid
B	$\mathbf{P_3}$	a gas that turns red litmus blue
	$\mathbf{P_4}$	a compound with bleaching properties
C	$\mathbf{P_5}$	a tribasic acid
	$\mathbf{P_6}$	a strong monobasic acid
D	$\mathbf{P_7}$	a gas that turns acidic $KMnO_4$ solution colourless
	$\mathbf{P_8}$	a colloidal solid
	$\mathbf{P_9}$	a strong monobasic acid

(i) Identify **A, B, C** and **D** (give the chemical formulae).

A: .... **B:** .... **C:** .... **D:** ....

(ii) Give balanced chemical equations for the reactions of **A, B, C** and **D** with water to give products $\mathbf{P_1}$ to $\mathbf{P_9}$.

....

....

....

....

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

I. P_1 with NaOH(aq)

....

II. P_3 with Mg

....

III. P_7 with acidic $K_2Cr_2O_7$

....

(50 *marks*)

(*b*) A student is provided with bottles labelled **P, Q, R, S, T** and **U** containing aqueous solutions of $Al_2(SO_4)_3$, H_2SO_4, $Na_2S_2O_3$, $BaCl_2$, $Pb(Ac)_2$ and KOH **(not in order)**. Some useful observations for their identification on mixing two solutions at a time are given below. (Ac - Acetate ion)

	Solutions mixed	**Observations**
I	**T + R**	a clear colourless solution
II	**P + R**	a white precipitate
III	**T + S**	a gelatinous white precipitate
IV	**U + R**	a white precipitate
V	**P + Q**	a white precipitate, turns black on heating
VI	**P + U**	a white precipitate, dissolves on heating

(i) Identify **P** to **U**.

P: .... **Q**: .... **R**: ....

S: .... **T**: .... **U**: ....

(ii) Give balanced chemical equations for each of the reactions **I** to **VI**.

I: ....

II: ....

III: ....

IV: ....

V: formation of white precipitate: ....

turning black on heating: ....

VI: ....

(**Note**: indicate precipitates as ↓)

(50 *marks*)

100

3. (*a*) A saturated aqueous solution of a sparingly soluble salt $AB_2(s)$ was prepared by stirring an excess amount of $AB_2(s)$ in 1.0 dm^3 of distilled water at 25 °C. The amount of $A^{2+}(aq)$ ions present in this saturated aqueous solution was found to be 2.0×10^{-3} mol.

(i) Write the equilibrium related to the dissolution of $AB_2(s)$ in the above system at 25 °C.

....

(ii) Write the expression for the equilibrium constant for the equilibrium written in (i) above at 25 °C.

....

....

[*see page six*

Do not write in this column.

(iii) Calculate the value of the equilibrium constant stated in (ii) above at 25 °C.

....

....

....

....

....

....

(iv) Another saturated aqueous solution of AB_2 was prepared by stirring an excess amount of $AB_2(s)$ in 2.0 dm^3 of distilled water at 25 °C. Giving reasons, predict the value of the equilibrium constant for this system.

....

....

(v) A small amount of the strong electrolyte NaB(s) is added to a saturated aqueous solution of AB_2 at 25 °C. Giving reasons, predict whether the concentration of $A^{2+}(aq)$ is increased or decreased.

....

....

....

(60 *marks*)

(*b*) In an aqueous solution, propanoic acid (C_2H_5COOH) ionizes as given below.

$$C_2H_5COOH(aq) + H_2O(l) \rightleftharpoons C_2H_5COO^-(aq) + H_3O^+(aq)$$

At 25 °C, K_a (propanoic acid) = 1.0×10^{-5}

(i) Write the expression for the equilibrium constant for the above reaction at 25 °C.

....

....

(ii) 100.0 cm^3 of an aqueous solution of $C_2H_5COOH(aq)$ was prepared by dissolving 0.74 cm^3 of C_2H_5COOH in distilled water at 25 °C. Calculate the pH of the solution at 25 °C.
(C = 12; O = 16; H = 1; consider the density of C_2H_5COOH as 1.0 g cm^{-3})

100

(40 *marks*)

[*see page seven*

Do not write in this column.

4. (*a*) **A, B, C** and **D** are structural isomers having the molecular formula C_6H_{10}. None of them show optical isomerism. All four isomers, **A, B, C** and **D** when treated with $HgSO_4$/dil. H_2SO_4 give products which react with 2,4-dinitrophenylhydrazine (2,4-DNP) to give coloured precipitates.

Only **A** gives a precipitate with ammonical $AgNO_3$. **A** has only one position isomer, which is **B**. **B** is a chain isomer of **C**. **C** reacts with $HgSO_4$/dil. H_2SO_4 to give two products **E** and **F**. **D** reacts with $HgSO_4$/dil. H_2SO_4 to give only one product, which is **E**.

(i) Draw the structures of **A, B, C, D, E** and **F** in the boxes given below.

A **B** **C**

D **E** **F**

(ii) Which of the compounds **A, B, C** and **D** gives a product that does not show diastereoisomerism when reacted separately with H_2 / Pd-$BaSO_4$ / quinoline?

(iii) Draw, in the box given below, the structure of the product **G** obtained when **A** is reacted with excess HBr.

G

(iv) Draw the structures of products **X** and **Y** obtained in the following reactions of **E**, in the appropriate boxes.

$$\mathbf{X} \xleftarrow[\text{Methanol}]{NaBH_4} \mathbf{E} \xrightarrow[2.\ H^+/H_2O]{1.\ C_2H_5MgBr} \mathbf{Y}$$

Name a test to distinguish between **X** and **Y**.

....

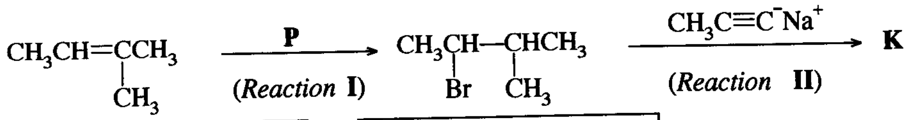
(60 *marks*)

[see page eight

Do not write in this column.

(*b*) (i) Complete the following three reaction sequences by drawing structures of compounds **K, L** and **M** and giving the reagents/catalysts **P, Q** and **R** in the boxes given below.

Sequence 1:

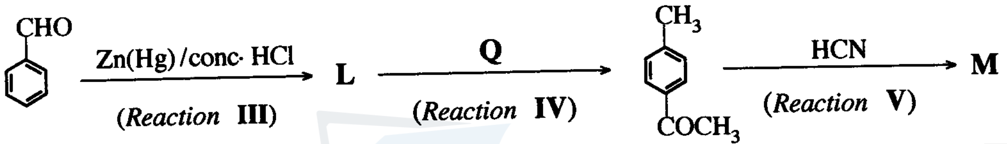


$CH_3CH{=}\underset{\substack{|\\CH_3}}{C}CH_3 \xrightarrow[\text{(Reaction I)}]{P} CH_3\underset{\substack{|\\Br}}{C}H-\underset{\substack{|\\CH_3}}{C}HCH_3 \xrightarrow[\text{(Reaction II)}]{CH_3C\equiv C^-Na^+} K$

P

K

Sequence 2:

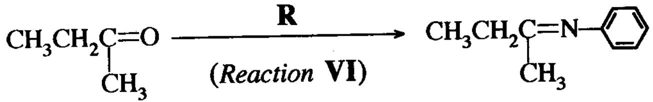


L

Q

M

Sequence 3:



R

(30 *marks*)

(ii) Selecting from the reactions **I – VI**, give **one (01)** example for each of the following types of reactions.

Nucleophilic addition ....

Nucleophilic substitution .... **(10 *marks*)**

100

* *

7048

නව නිර්දේශය / புதிய பாடத்திட்டம் / New Syllabus

NEW

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

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2020
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2020
General Certificate of Education (Adv. Level) Examination, 2020

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* **150** ***marks.***)

5. (*a*) A compound $XY_2Z_2(g)$ undergoes dissociation when heated to temperatures above 300 K as given below.

$$XY_2Z_2(g) \overset{\Delta}{\rightleftharpoons} XY_2(g) + Z_2(g)$$

A sample of 7.5 g of $XY_2Z_2(g)$ was placed in an evacuated 1.00 $\mathrm{dm^3}$ rigid-closed container and the temperature was raised to 480 K.
Molar mass of $XY_2Z_2(g)$ is 150 $\mathrm{g\ mol^{-1}}$. Use the approximate value of 4000 $\mathrm{J\ mol^{-1}}$ for RT at 480 K. Assume ideal gas behaviour for all gases.

(i) Calculate the number of moles of $XY_2Z_2(g)$ in the container before dissociation.

(ii) When the above system reaches equilibrium at 480 K, the total number of moles in the container was found to be 7.5×10^{-2} mol. Calculate the number of moles of $XY_2Z_2(g)$, $XY_2(g)$ and $Z_2(g)$ in the equilibrium mixture at 480 K.

(iii) Calculate the equilibrium constant K_c for the above reaction at 480 K.

(iv) Calculate K_p for the equilibrium at 480 K. **(75 *marks*)**

(*b*) For the reaction $XY_2Z_2(g) \rightarrow XY_2(g) + Z_2(g)$ described in (a), Gibbs free energies (G) at 480 K for $XY_2Z_2(g)$, $XY_2(g)$ and $Z_2(g)$ are $-60\ \mathrm{kJ\ mol^{-1}}$, $-76\ \mathrm{kJ\ mol^{-1}}$ and $-30\ \mathrm{kJ\ mol^{-1}}$, respectively.

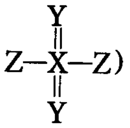
(i) Calculate ΔG (in $\mathrm{kJ\ mol^{-1}}$) for the reaction at 480 K.

(ii) The magnitude of ΔS of the above reaction is 150 $\mathrm{J\ K^{-1}\ mol^{-1}}$ at 480 K. Calculate ΔH for the reaction at 480 K by using the appropriate sign (– or +) of ΔS.

(iii) By using the sign (– or +) of ΔH obtained in (ii), explain whether this reaction is exothermic or endothermic.

(iv) Deduce the enthalpy difference for the formation of $XY_2Z_2(g)$ from $XY_2(g)$ and $Z_2(g)$ at 480 K.

(v) If the bond enthalpy of the X–Z bond in $XY_2Z_2(g)$ is +250 $\mathrm{kJ\ mol^{-1}}$, calculate the bond enthalpy of the Z–Z bond.

(Assume that $XY_2Z_2(g)$ has the structure  $Z{-}\overset{\overset{\displaystyle Y}{\|}}{\underset{\underset{\displaystyle Y}{\|}}{X}}{-}Z$)

(vi) If liquid XY_2Z_2 is used instead of gaseous XY_2Z_2, giving reasons, explain whether the value of ΔH obtained for the reaction $XY_2Z_2(l) \rightarrow XY_2(g) + Z_2(g)$ is equal to, or higher or lower than ΔH obtained in (ii).

(75 *marks*)

[*see page ten*

6. (*a*) Consider the reaction given below occurring in a closed container at a given temperature T.

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

(i) Write **three** expressions for the rate of reaction relevant to each of the compounds appearing in the reaction.

(ii) This reaction was carried out at temperature T with an initial concentration of 0.10 mol dm^{-3} of $N_2O_5(g)$. It was found that 40% of the initial amount was decomposed after a period of 400 s.

I. Calculate the average rate of decomposition of $N_2O_5(g)$ in this time interval.

II. Calculate average rates of formation of $NO_2(g)$ and $O_2(g)$.

(iii) In another experiment, initial rates were measured for this reaction at 300 K and the results are given below.

$[N_2O_5(g)]$ / mol dm^{-3}	0.01	0.02	0.03
Initial rate / mol dm^{-3} s^{-1}	6.930×10^{-5}	1.386×10^{-4}	2.079×10^{-4}

Derive the rate law for the reaction at 300 K.

(iv) Another experiment was carried out at 300 K with an initial concentration of 0.64 mol dm^{-3} of $N_2O_5(g)$. It was found that the concentration of $N_2O_5(g)$ which remained after a period of 500 s was 2.0×10^{-2} mol dm^{-3}.

I. Calculate the half-life ($t_{1/2}$) of the reaction at 300 K.

II. Calculate the rate constant of the reaction at 300 K.

(v) This reaction proceeds through a mechanism involving the following elementary steps.

Step 1 : $N_2O_5(g) \rightleftharpoons NO_3(g) + NO_2(g)$: Fast

Step 2 : $NO_3(g) + NO_2(g) \rightarrow 2NO_2(g) + O(g)$: Slow

Step 3 : $N_2O_5(g) + O(g) \rightarrow 2NO_2(g) + O_2(g)$: Fast

Show that the above mechanism is consistent with the rate law of the reaction. **(80 *marks*)**

(*b*) An ideal binary-liquid mixture was prepared by mixing two liquids of **A** and **B** in a closed evacuated container at temperature T. After establishing the equilibrium at temperature T, partial pressures of **A** and **B** in the vapour phase are P_A and P_B, respectively. At temperature T, the saturated vapour pressures of **A** and **B** are P_A° and P_B°, respectively. Mole fractions of **A** and **B** in solution are X_A and X_B, respectively.

(i) Show that $P_A = P_A^\circ X_A$

(Consider that the rates of vaporization and condensation are equal at equilibrium.)

(ii) In the above system at 300 K, the total pressure was 5.0×10^4 Pa. The saturated vapour pressures of pure **A** and **B** at 300 K, are 7.0×10^4 Pa and 3.0×10^4 Pa, respectively.

I. Calculate the mole fraction of **A** in the liquid phase of the equilibrium mixture.

II. Calculate the vapour pressure of **A** in the equilibrium mixture.

(70 *marks*)

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7\. (*a*) (i) To compare the properties of Electrolytic and Galvanic cells, copy and complete the following table using the given terms.

Terms: anode, cathode, positive, negative, spontaneous, non-spontaneous.

		Electrolytic cell	**Galvanic cell**
A.	Oxidation half-reaction takes place at		
B.	Reduction half-reaction takes place at		
C.	Sign of E°_{cell}		
D.	Electron flow	From .... to	From .... to ....
E.	Spontaneity of the cell reaction		

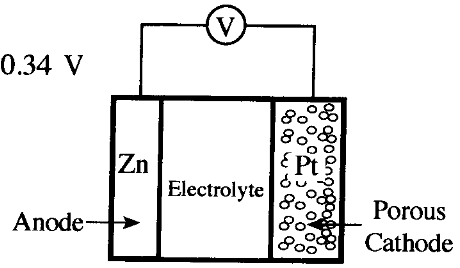
(ii) An electrochemical cell was constructed at 300 K by using a Zn(s) anode, an aqueous alkaline electrolyte and a porous Pt cathode which facilitates the collection of oxygen $O_2(g)$ from air as shown below. As the cell operates ZnO(s) is produced.

You are given that

$E^{\circ}_{ZnO(s)\,|\,Zn(s)\,|\,OH^{-}(aq)} = -1.31$ V and $E^{\circ}_{O_2(g)\,|\,OH^{-}(aq)} = +0.34$ V

Zn = 65 g mol^{-1}, O = 16 g mol^{-1} and

1 *F* = 96,500 C



I. Write the half-reactions occurring at anode and cathode.

II. Write the overall cell reaction.

III. Calculate the cell potential E°_{cell} at 300 K.

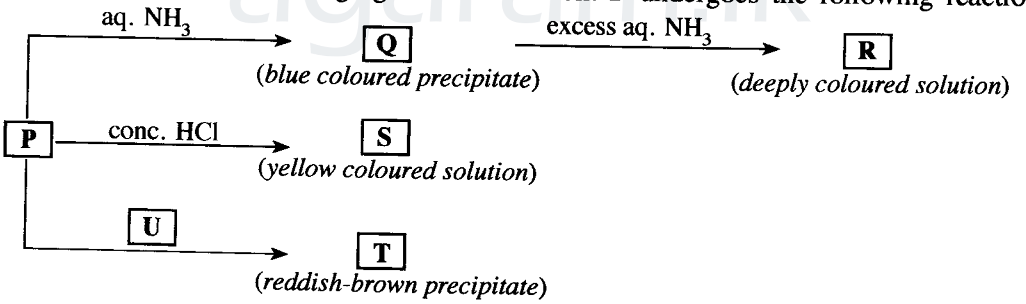
IV. State the direction of migration of $OH^{-}(aq)$ ions between the electrodes.

V. When the cell operates for a period of 800 s at 300 K, 2 mol of $O_2(g)$ are consumed.

- A. Calculate the number of moles of electrons passing through the cell.
- B. Calculate the mass of ZnO(s) formed.
- C. Calculate the current passing through the cell.

(75 *marks*)

(*b*) A coloured complex ion **P** is formed when the salt $\mathbf{M}(NO_3)_n$ is dissolved in distilled water. **M** is a transition element belonging to the 3*d* block. **P** undergoes the following reactions.



T and **U** are coordination compounds each containing four elements. **P, R** and **S** are complex ions.

(i) Identify the metal **M**. Give the oxidation state of **M** in complex ion **P**.

(ii) Give the value of n in $\mathbf{M}(NO_3)_n$.

(iii) Write the complete electronic configuration of **M** in complex ion **P**.

(iv) Write the chemical formulae of **P**, **Q**, **R**, **S**, **T** and **U**.

(v) Give the IUPAC names of **P**, **R**, **S**, **T** and **U**.

(vi) What is the colour of **P**?

(vii) What would you expect to observe in I and II given below?

I. When H_2S gas is passed into an acidic solution containing **P** at room temperature

II. When the mixture obtained in I above is heated with dilute HNO_3 after the removal of dissolved H_2S

(viii) Briefly describe a method with the aid of balanced chemical equations for determining the concentration of $\mathbf{M}^{n+}$ present in an aqueous solution, using the following chemicals.

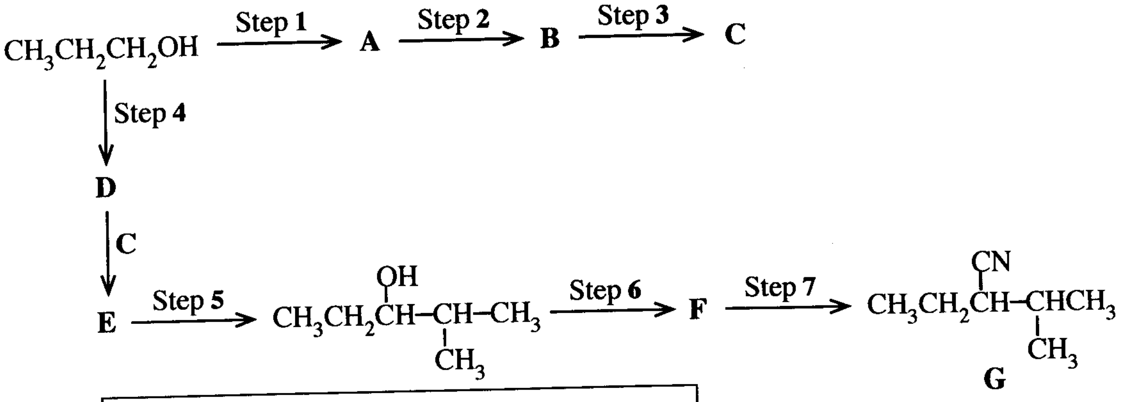
KI, $Na_2S_2O_3$ and starch.

(75 *marks*)

PART C — ESSAY

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

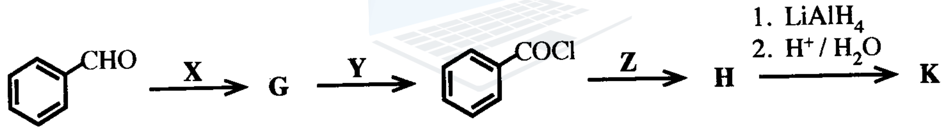
8. (*a*) (i) Given below is a reaction scheme for the synthesis of compound **G** using $CH_3CH_2CH_2OH$ as the only organic starting compound.
Complete the reaction scheme by drawing the structures of compounds **A, B, C, D, E** and **F** and writing the appropriate reagents for steps **1** – **7**, selected only from those given in the list.

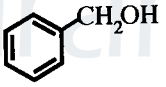


List of Reagents
HBr, PBr_3, pyridiniumchlorochromate (PCC), Mg / dry ether, KCN, conc. H_2SO_4, dil. H_2SO_4

(**52** ***marks***)

(ii) Consider the following series of reactions.
Draw the structures of compounds **G, H** and **K**. Give the reagents **X, Y** and **Z**.

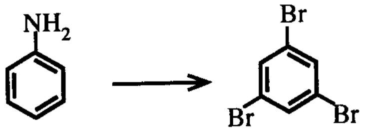


Note that **K** gives benzyl alcohol (

) when reacted with $NaNO_2$/ dil. HCl.

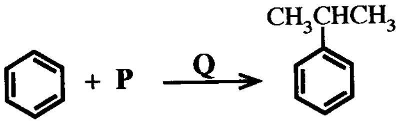
(**24** ***marks***)

(*b*) (i) Show how the following conversion could be carried out in **not more than three** steps.



(**20** ***marks***)

(ii) Consider the following reaction.



Identify the chemical substances **P** and **Q** necessary to carry out this reaction.
Write the mechanism of this reaction. (**20** ***marks***)

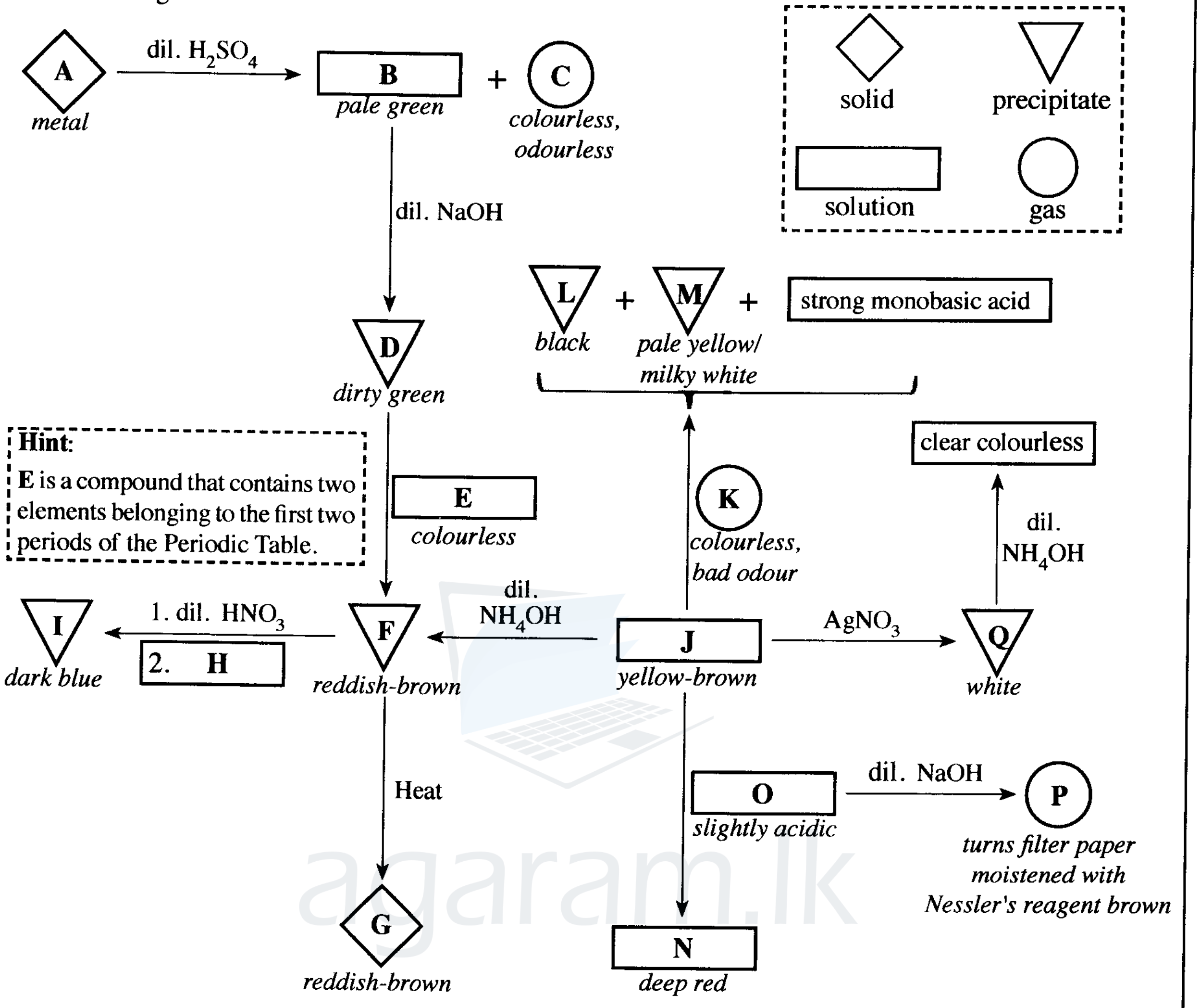
(*c*) (i) Explain why phenol is more reactive in electrophilic substitution reactions than benzene, by considering their resonance hybrids.

(ii) Illustrate the difference in reactivity between phenol and benzene as given in (i) above by means of a suitable reaction.

(iii) Draw the structure(s) of product(s) you described in the reaction in (ii) above. (**34** ***marks***)

[*see page thirteen*

9. (*a*) (i) Write the chemical formulae of the substances **A** – **Q** given in the flow chart below.
(**Note**: Chemical equations and reasons are not expected for the identification of substances **A** – **Q**.)
The symbols given in the box (dash lines) are used to represent solids, precipitates, solutions and gases.



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

(iii) State the function of **E** in the conversion of **D** to **F**. Give the relevant balanced chemical equations for the stated function. **(75 *marks*)**

(*b*) The solid **X** contains only Cu_2S and CuS. The following procedure was used to determine the percentage of Cu_2S in **X**.

Procedure

A 1.00 g portion of solid **X** was treated with 100.00 cm^3 of 0.16 mol dm^{-3} $KMnO_4$ in dilute H_2SO_4 medium. This reaction gave Mn^{2+}, Cu^{2+} and SO_4^{2-} as products. Thereafter, the excess $KMnO_4$ in this solution was titrated with 0.15 mol dm^{-3} Fe^{2+} solution. The volume required for the titration was 35.00 cm^3.

(i) Write the balanced ionic equations for the reactions taking place in the above procedure.

(ii) Based on the answers to (i) above, determine the molar ratio between,

I. Cu_2S and $KMnO_4$
II. CuS and $KMnO_4$
III. Fe^{2+} and $KMnO_4$

(iii) Calculate the percentage by weight of Cu_2S in **X**. (Cu = 63.5, S = 32) **(75 *marks*)**

[*see page fourteen*

10. (*a*) The following questions are based on the properties of titanium dioxide (TiO_2) and its manufacture carried out by the "Chloride Process".

(i) Name the raw materials used in this process.

(ii) Briefly describe the manufacturing process of TiO_2 giving balanced chemical equations where applicable.

(iii) State **three** properties of TiO_2 and give one use each, relevant to each property.

(iv) If you were to consider establishing a TiO_2 manufacturing plant in Sri Lanka, state **three** requirements that need to be fulfilled.

(v) Does the manufacturing process described in (ii) above contribute to global warming? Justify your answer. **(50 *marks*)**

(*b*) Currently, global warming due to change in greenhouse effect is significantly greater than that before the industrial revolution.

(i) Explain briefly what is meant by greenhouse effect.

(ii) Identify the major environmental problem that occurs due to global warming.

(iii) State **two main** natural gases that contribute to global warming.

(iv) Explain briefly how microorganisms contribute to the release of the gases you stated in (iii).

(v) In addition to the gases you stated in (iii), name **two** classes of synthetic volatile compounds that directly contribute to the global warming, and selecting one compound from each class, draw their structures.

(vi) Select **one** class of compounds from the two classes you stated in (v) that contributes to the catalytic degradation of ozone in the upper atmosphere.

(vii) The slow down of industrial activities due to the Covid-19 pandemic temporarily eased the global environmental issues in many countries. Justify this statement by using **two** main global environmental issues you have learnt. **(50 *marks*)**

(*c*) The following questions are based on the polymers given below.

Polyvinyl chloride (PVC), Polyethylene (PE), Polystyrene (PS), Bakelite,
Nylon 6.6, Polyethylene terephthalate (PET), Gutta percha

(i) Draw the repeating units of **four** of the above polymers.

(ii) Categorize each of the above seven (7) polymers as either,

I. natural or synthetic polymers.
II. addition or condensation polymers.

(iii) Name the **two** monomers used in the formation of bakelite.

(iv) Polymers can be grouped into two categories based on their thermal properties. State these **two** categories. Write to which of these categories PVC and bakelite belong.

(v) Give **one** use each for **three** of the polymers given in the above list. **(50 *marks*)**

* * *

[see page fifteen

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**